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THESIS

COST-ATTRIBUTE ANALYSIS OF RESTRUCTURING H-60R/S FLEET REPLACEMENT SQUADRONS

by

Julia M. Lopez

December 2000

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The U.S. Navy helicopter community will soon experience an unprecedented transformation; one that will see a massive shift in the identity of the community and in its fleet operations. In accordance with the Helicopter Master Plan (HMP), two new airframes, the SH-60R and CH-60S, will replace the existing helicopter inventory. This thesis develops the optimal way to structure the Fleet Replacement Squadrons (FRS's), specifying the location of the various FRS's and other training necessities. Four organizational options for restructuring the FRS's are considered: two separate airframe specific FRS's per coast, one combined FRS per coast, one FRS per airframe, and one single site combined FRS. Two different training plans are considered with each option. These training plans will consider whether or not to consolidate those portions of the syllabus common to both airframes. Training, maintenance, and support cost data are determined through the use of VAMOSC data and historical annual training requirements. A thorough attribute analysis of the different alternatives is performed. Using standard economic analysis techniques, multi-attribute decision theory is applied to enable a commander to choose the best option for FRS restructuring. When cost attributes are varied, the recommended alternative is to have two separate FRS's in NAS North Island, and two separate FRS's in NAS Jacksonville/Mayport.

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COST-ATTRIBUTE ANALYSIS OF RESTRUCTURING H-60R/S FLEET REPLACEMENT SQUADRONS

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Lieutenant, United States Navy
B.S., United States Naval Academy, 1993

Submitted in partial fulfillment of the
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ABSTRACT

The U.S. Navy helicopter community will soon experience an unprecedented transformation; one that will see a massive shift in the identity of the community and in its fleet operations. In accordance with the Helicopter Master Plan (HMP), two new airframes, the SH-60R and CH-60S, will replace the existing helicopter inventory. This thesis develops the optimal way to structure the Fleet Replacement Squadrons (FRS's), specifying the location of the various FRS's and other training necessities. Four organizational options for restructuring the FRS's are considered: two separate airframe-specific FRS's per coast, one combined FRS per coast, one FRS per airframe, and one single site combined FRS. Two different training plans are considered with each option. These training plans will consider whether or not to consolidate those portions of the syllabus common to both airframes. Training, maintenance, and support cost data are determined through the use of VAMOSC data and historical annual training requirements. A thorough attribute analysis of the different alternatives is performed. Using standard economic analysis techniques, multi-attribute decision theory is applied to enable a commander to choose the recommended option for FRS restructuring. When cost attributes are varied, the best alternative is to have two separate FRS's in NAS North Island, and two separate FRS's in NAS Jacksonville/Mayport.

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TABLE OF CONTENTS

I. INTRODUCTION 1

A. PROBLEM DEFINITION 1

B. U.S. NAVY HELICOPTER TRAINING ORGANIZATION 2

1. Training 2

2. Fleet Replacement Squadrons (FRS) 3

C. FLEET ORGANIZATION 3

D. HELICOPTER MASTER PLAN 5

II. DESCRIPTION OF ORGANIZATIONAL ALTERNATIVES 7

A. INTRODUCTION 7

B. DESCRIPTION OF INFRASTRUCTURE OPTIONS 7

1. Option 1 – Quad 8

2. Option 2 - Pair 9

3. Option 3 – Coastal 9

4. Option 4 – Mono 9

C. DESCRIPTION OF TRAINING PLANS 10

1. Plan A: Status Quo 10

2. Plan B: Common Cockpit Syllabus Training 10

D. ASSUMPTIONS 12

1. Student Throughput 12

2. Syllabus Characteristics 13

3. Fleet Squadron Locations 14

III. COST ANALYSIS 17

A. BACKGROUND 17

B. PROCUREMENT COSTS 17

1. Unit Procurement Costs 17

2. Hangar Availability 18

3. *Simulator Availability* 19
4. *Procurement Cost Results* 19
C. ANNUAL TRAINING COSTS 20
1. *Cost Per Flight Hour* 20
2. *Permanent Change of Station (PCS) Costs* 22
3. *Annual Training Cost Results* 22
D. TOTAL COSTS 23
IV. ANALYSIS OF NON-MONETARY ATTRIBUTES 25
A. METHODOLOGY 25
B. DEFINITION OF ATTRIBUTES 25
1. *Number of Squadrons Established/Disestablished* 25
2. *Officer-To-Enlisted Ratio* 27
3. *Number of Permanent Change of Station (PCS) Moves Required* 27
4. *Flight Hours per Month per Aircraft* 28
V. SCORING AND SELECTION OF ALTERNATIVES 29
A. ADDITIVE WEIGHTING AND SCALING MODEL 29
1. *Definition* 29
2. *Application* 29
B. RESULTS 31
1. *Attribute Score (Raw Score Without Weight Applied)* 32
2. *Individually Weighted Attribute Scores* 33
3. *Weighted Attribute Simulation* 35
VI. SENSITIVITY ANALYSIS 37
A. INTRODUCTION 37
B. SYLLABUS CHARACTERISTICS 38
1. *Maintenance FMC/MC Rates* 38
C. COST PER FLIGHT HOUR 39
D. PROCUREMENT COST 40

D. SENSITIVTY ANALYSIS CONCLUSIONS 40

1. Cost Attribute Ratio Score *40*

2. Tornado Graphs *42*

VII. CONCLUSIONS 45

APPENDIX A: SQUADRON REQUIREMENT FORMULATION 49

APPENDIX B: ALTERNATE SQUADRON PRESENTATION 55

LIST OF REFERENCES 61

INITIAL DISTRIBUTION LIST 63

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LIST OF FIGURES

Figure 1: From Ref. 6, Current U.S. Navy Helicopter Squadron Locations. 4
Figure 2: From Ref. 6, Helicopter Master Plan (HMP). 5
Figure 3: Illustration of Training Plans A and B. 11
Figure 4: After Ref. 6, Potential Organization for Future U.S. Navy Helicopter Squadron Locations. 15
Figure 5: Aircraft Procurement Costs, FY01 20
Figure 6: Annual Training Costs for Each Alternative, FY01. 23
Figure 7: Total Cost for Alternatives, FY01. 24
Figure 8: Selection of Alternatives - Cost Attribute Ratio, Attribute Weight Simulation 36
Figure 9: Sensitivity Analysis - CAR Attribute Weight Simulation. 41
Figure 10: Tornado Graph for Total Cost of Quad Alternative 2B. 43

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LIST OF TABLES

Table 1: Description of Organizational Alternatives 8
Table 2: Projected FY12 Student Requirements By Fleet Squadron. 12
Table 3: Fixed Syllabus Characteristics. 13
Table 4: VAMOSC '92-'97 Costs per Flight Hour for the SH-60B and HH-60H Helicopters. 21
Table 5: Raw Attribute Scores for Each Alternative 26
Table 6: Scoring and Selection of Alternatives, Unweighted Cost Attribute Ratio Scores. 32
Table 7: Baseline, Reduced, and Increased Cost Per Flight Hour. 39

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EXECUTIVE SUMMARY

In accordance with the Helicopter Master Plan (HMP), the U.S Navy is introducing two new helicopter variants, the SH-60R and CH-60S. The two new variants will transition the U.S. Navy helicopter inventory from seven Type/Model/Series down to two. The reduction in the number of airframe variants offers an opportunity to reorganize the Fleet Replacement Squadrons (FRS), which are devoted to pilot training.

Four organizational options for reorganizing the FRS's are suggested. These four options are further broken down into two distinct training plans and several geographic variants. The two training plans address whether or not to consolidate those portions of the FRS syllabus common to both airframes (common cockpit syllabus). In the "common cockpit" syllabus, student pilots will receive the entire common cockpit syllabus in the CH-60S airframe. In the "status quo" syllabus, student pilots will receive the entire syllabus in their fleet specific aircraft. The four options, plus two training plans, and multiple geographic options result in twenty-two alternatives for analysis.

Each of the alternatives is studied to determine the resulting costs and attributes. Costs are comprised of procurement costs, annual training costs, and Permanent Change of Station (PCS) costs. Procurement costs are those costs associated with purchasing the aircraft, hangars, and simulators required for each alternative. Annual training costs are estimated using historical cost per flight hour from the Navy's Visibility and Management of Operating and Support Costs (VAMOSC) database. PCS costs are those costs incurred if a given alternative requires the transfer of a student pilot across the country or within the east coast. These costs are then used to determine the total annual cost for each option.

Five non-monetary attributes, are evaluated for each alternative: the number of squadrons disestablished, the number of squadrons established, officer-to-enlisted ratio, the number of PCS moves required, and the flight hours per month per aircraft. Each alternative receives a raw score in the aforementioned attributes.

An additive weighting and scaling model is used to select the preferred training alternatives. Three perspectives are considered. First, the alternatives are ranked according to their unweighted Cost-Attribute Ratio (CAR) score. Second, the alternatives are evaluated with respect to each individual attribute. Third, a simulation is performed to consider the multiple ways in which various decision-makers might weigh the alternatives. From this simulation, a decision-maker is able to evaluate the CAR score in terms of both magnitude and variability when attribute weights are varied. Through all three of these approaches, the cost-attribute ratios are then analyzed to select the preferred training alternative.

Sensitivity analysis is then performed on three primary inputs: the Fully Mission Capable (FMC) and Mission Capable (MC) rates, cost per flight hour, and procurement cost.

The analysis reveals a group of four alternatives that are the most preferred due to their CAR score as well as low variability with respect to changes in decision-maker weighing preferences. This group involves an FRS structure in which SH-60R and CH-60S training is conducted in separate FRS squadrons on both coasts, with NAS North Island and NAS Jacksonville/NAS Mayport being the preferred geographic locations.

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I. INTRODUCTION

A. PROBLEM DEFINITION

As part of the implementation of the Helicopter Master Plan (HMP), the U.S. Navy introduced two new airframes in the fall of 2000. The two new variants, the SH-60R and the CH-60S will assume the roles of all existing helicopters in the U.S. Navy. Specifically, the SH-60R will cover mission areas previously belonging to the SH-60B/F, while the CH-60S will handle all other mission areas, including organic airborne mine counter measures (OAMCM) and Combat Search and Rescue (CSAR). The reduction in the number of airframe variants offers an opportunity to reorganize the Fleet Replacement Squadrons (FRS) infrastructure to increase efficiency in supplying trained pilots to the fleet.

This thesis is considering four organizational options for restructuring the FRS: (1) two separate airframe-specific FRS's per coast, (2) one combined FRS per coast, (3) one airframe specific FRS per airframe, and (4) one single site combined FRS. Two different training plans are applied to these alternatives. The two training plans consider whether or not to consolidate those portions of the syllabus common to both airframes. While the SH-60R and CH-60S have identical cockpits, their aft sections differ due to mission specific equipment. The portion of the FRS syllabus revolving around this commonality up to the Naval Air Training and Operating Procedures (NATOPS) qualification is common to both the SH-60R and the CH-60S. The first option maintains the current pipeline: each student pilot will train solely in his or her ultimate fleet specific aircraft. The second option considers the common cockpit syllabus: student pilots receive the entire common cockpit syllabus in the CH-60S airframe, regardless of the type of aircraft he or she will ultimately fly in the Fleet. A student pilot completes FRS training in the ultimate Fleet specific aircraft.

The goal of this thesis is to conduct an economic analysis of these alternatives, enabling decision-makers to determine how best to proceed with the potential restructuring of the FRS's.

B. U.S. NAVY HELICOPTER TRAINING ORGANIZATION

1. Training

Pilots arrive at the FRS with a variety of skill levels. The student pilots consist of new accessions, pilots upgrading to a new variant of helicopter, and fleet experienced pilots returning from disassociated sea or shore tours for refresher training. Currently, initial accession student naval aviators selected to train as helicopter pilots complete both a primary and an advanced helicopter syllabus at Whiting Field in Milton, Florida. Upon successful completion of this training, the student pilots are designated as Naval Aviators and continue to a Fleet Replacement Squadron.

All designated Naval Aviators are assigned to training at the FRS based upon time out of the cockpit rather than ultimate billet assignment. The aviators arriving for training at the FRS fall into five categories: Category I (CAT I), Category II (CAT II), Category III (CAT III), Category IV (CAT IV), and Category V (CAT V).

CAT I student pilots experience a complete syllabus for "first-tour in model" (OPNAV, April 1999). CAT II status is assigned to a Naval Aviator transitioning from another like aircraft; for example a CH-46D transitioning to an SH-60F. CAT II pilots require a transition syllabus, usually 85% of the complete syllabus for a CAT I pilot. CAT III student pilots are those aviators returning to an operational Fleet squadron after being out of the cockpit for a period of 18 months or longer. Historically, these pilots require 70% of the CAT I syllabus. CAT IV student pilots are typically Prospective Executive Officers (PXOs), who require a minimal refresher syllabus, typically 50% of the CAT I syllabus. CAT V is a special category used only for unique student pilots, such as foreign military pilots. A CAT V syllabus is uniquely determined for the specific pilot and need.

2. Fleet Replacement Squadrons (FRS)

At the FRS, all student pilots undergo training in their future fleet specific aircraft. The syllabus consists of cockpit and simulator training, followed by specialized training learning how to operate the mission specific equipment in the helicopter. With the introduction of the SH-60R and CH-60S airframes, all helicopter pilots will require training in the new aircraft. Once the helicopter community has transitioned to the SH-60R and CH-60S, no requirement to train CAT II pilots is anticipated. Therefore, the majority of aviators arriving at the FRS for training in either the SH-60R or the CH-60S will be CAT I, CAT III, or CAT IV pilots.

C. FLEET ORGANIZATION

Currently, squadrons and their pilots are organized according to mission area: Helicopter Anti-Submarine Light (HSL) squadrons, Helicopter Anti-Submarine (HS) squadrons, Helicopter Mine Warfare (HM) squadrons, and Helicopter Combat Support (HC) squadrons. Similar airframes are present in some or all of these squadrons. With the arrival of the SH-60R and CH-60S airframes, helicopter squadrons will be organized according to airframe type; squadrons will be notionally structured as either SH-60R or CH-60S squadrons. For pilots of all experience levels, the first exposure to the new aircraft will occur in the FRS's.

In the existing infrastructure there are five FRS's (see Figure 1). The FRS's are all located near Fleet Squadrons. There is one HSL FRS per coast located at Naval Air Station North Island, San Diego, California (NASNI) and Naval Air Station Mayport Florida (NAS MYPT). There is one single-site HS FRS at NASNI.

Naval Air Station Jacksonville, Florida (NAS JAX), and NAS MYPT are located within the same geographic location. With regard to potential restructuring of the FRS organization, their resources and training necessities are considered as a combined

geographic alternative. There are no FRS's currently located at NAS JAX. One HC FRS is located on each coast, at NASNI and Naval Air Station Norfolk (NORVA).

HC-2, located at NASNI, requires further comment. HC-2 is not a stand alone FRS similar to other FRS in existence. HC-2 is actually a department within a Fleet Squadron. The FRS portion of this squadron does not have a separate chain of command, maintenance department, or hangar. The current inventory of aircraft in the squadron is 16, of which 4 are specified for FRS use.

Proximity to the Fleet is a significant issue for the FRS's. Many FRS training facilities and resources are shared, resulting in near continual use; simulators, for example, provide valuable and required training for Fleet Squadrons as well as for the FRS's.

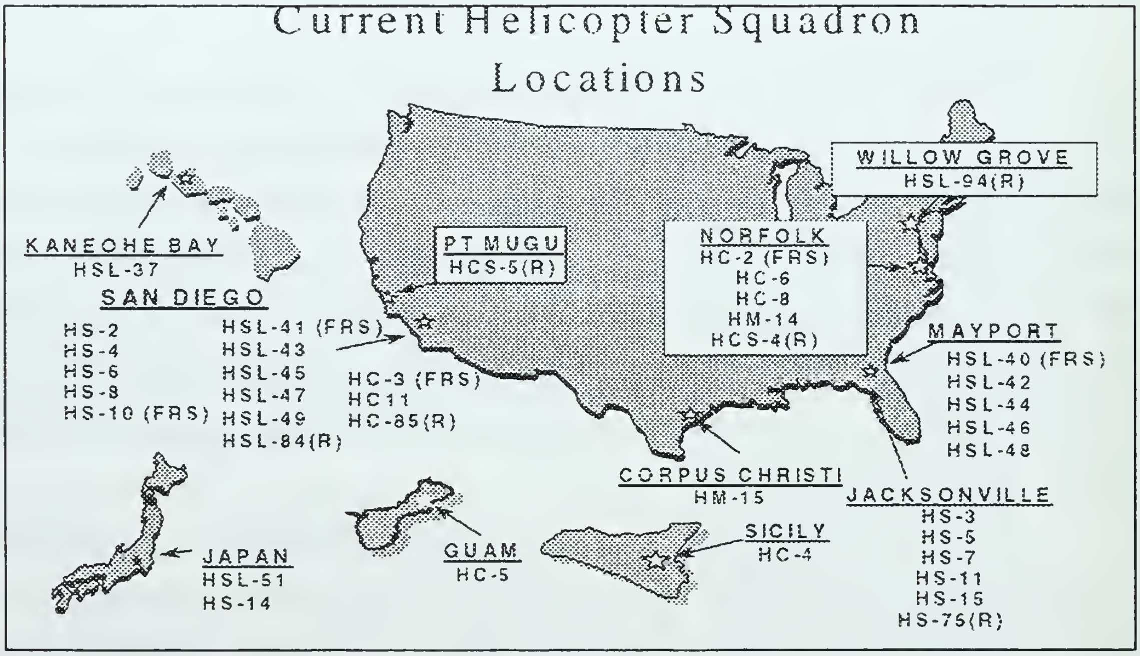

Figure 1: From Ref. 7, Current U.S. Navy Helicopter Squadron Locations. Depicted are the current squadron locations for the U.S Navy Helicopter community.

D. HELICOPTER MASTER PLAN

The purpose of the Helicopter Master Plan (HMP) is to streamline and transition from seven Type/Model/Series down to two. Figure 2 illustrates the timeline for this plan. The SH-60B/F missions will be assigned to the SH-60R T/M/S. The CH-60S T/M/S will be responsible for the remaining missions currently being met by the H-3, H-46, and H-60H with the addition of the Organic Anti-Mine Counter Measure (OAMCM) mission. The AMCM mission is currently performed by the MH-53. Research and development on the performance of the mission specific equipment to be installed in the rear of the CH-60S is still in progress. However, testing to date has confirmed the CH-60S will be capable of performing the OAMCM mission: accordingly the HM community is expected to merge into the CH-60S community, in accordance with the HMP.

The previously existing communities will be incrementally transitioned to the new SH-60R and CH-60S communities taking their place. Helicopter pilots will no longer be identified as HS, HSL, HC or HM pilots; they will, instead, be distinguished as either SH-60R or CH-60S pilots.

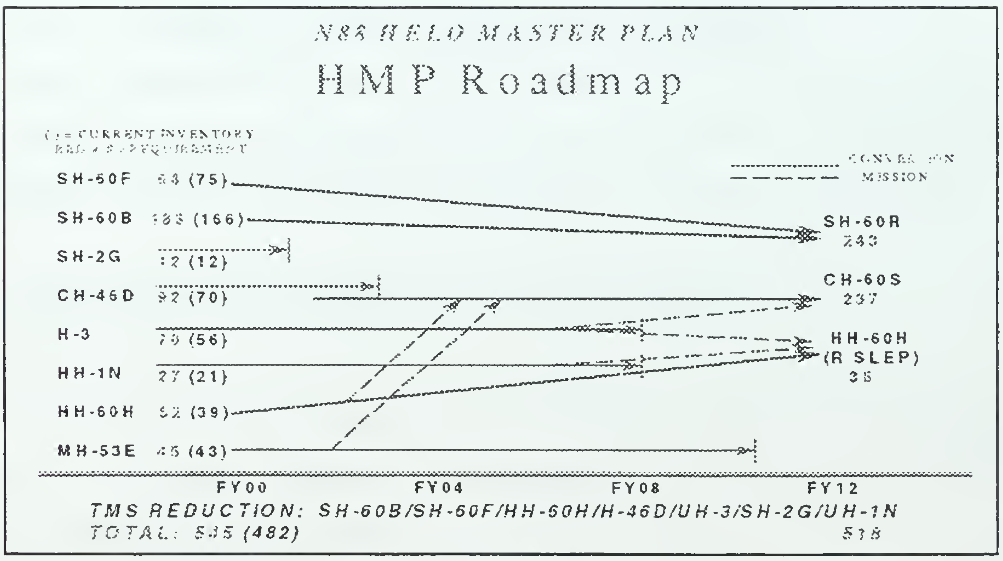

Figure 2: From Ref. 7, Helicopter Master Plan (HMP) . The roadmap illustrates the current path towards the U.S. Navy helicopter community reorganization. The phase out and phase in dates for each Type/Model/Series (T/M/S) is noted, as are the reallocation of mission for each airframe.

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II. DESCRIPTION OF ORGANIZATIONAL ALTERNATIVES

A. INTRODUCTION

In view of the significant change to the helicopter community, a determination of the most beneficial FRS infrastructure is desired. Four different organizational options are studied. In addition, each option also considers different combinations of geographic locations:

Option 1 ("Quad"): Two separate, airframe specific FRS's per coast (for a total of four squadrons, with two geographic options).

Option 2 ("Pair"): One combined SH-60R/S FRS on each coast (for a total of two squadrons, with two geographic options).

Option 3 ("Coastal"): One airframe specific FRS per airframe (for a total of two squadrons with four geographic options).

Option 4 ("Mono"): One single site combined FRS (for a total of one squadron, with three geographic options).

Each alternative is further broken down into two distinct training plans:

Plan A. Conduct entire syllabus on fleet specific airframe.

Plan B. Merge initial common cockpit training to use less expensive CH-60S.

Together, these four options and two plans (plus each option's specific geographic combination), create twenty-two different alternatives for study, as listed in Table 1.

B. DESCRIPTION OF INFRASTRUCTURE OPTIONS

Currently, the official designation for the SH-60R, CH-60S, squadron names and numbers, have not been identified. For the purpose of clarification, the following labeling convention has been applied:

HR: SH-60R squadron. (1) West Coast. (2) East Coast

HS: CH-60S squadron.

HRS: Combined SH-60R and CH-60S squadron.

Option	Alternative	No. of Squadrons	Airframe Assignments			Combined (C) or Specific (S) Squadrons
			NASNI	JAX/MYPT	NORVA	
1	1	4	HR-1WEST, HS-1 WEST	HR-2SEAST	HS-2NEAST	S
QUAD	2	4	HR-1WEST, HS-1 WEST	HR-2SEAST, HS-2SEAST		S
2	1	2	HRS-1WEST		HRS-2NEAST	C
PAIR	2	2	HRS-1WEST	HRS-2SEAST		C
3	1	2	HR WEST		HS NEAST	S
COASTAL	2	2	HR WEST	HS SEAST		S
	3	2	HR WEST, HS WEST			S
	4	2	HS WEST	HR NEAST		S
4	1	1	HRS WEST			C
MONO	2	1			HRS NEAST	C
	3	1		HRS SEAST		C

Table 1: Description of Organizational Alternatives. The four different organizational alternatives are listed. Also included is the total number of squadrons, airframe assignment for each squadron at each location, and the type of squadron involved for each alternative.

1. Option 1 – Quad

This option entails separate SH-60R and CH-60S FRS's on each coast. Two geographic alternatives are considered: first, one CH-60S squadron (HR-1 WEST) and one SH-60R squadron (HS-1 WEST) in NASNI plus one CH-60S squadron (HS-2 NEAST) in NAS Norfolk, and one SH-60R squadron (HR-2 SEAST) in NAS Jax/Mayport.

The second geographic alternative considers one CH-60S squadron (HS-1 WEST) and one SH-60R squadron (HR-1 WEST) in NASNI plus one CH-60S squadron (HS-2 SEAST) and one SH-60R squadron (HR-2 SEAST) in NAS Jax/Mypt.

2. Option 2 - Pair

In this option, the FRS organization consists of two combined SH-60R and CH-60S squadrons located on each coast. The two geographic alternatives consider NASNI (HRS-1 WEST) and NAS Norfolk (HRS-2 NEAST), and NASNI (HRS-1 WEST) and NAS Jax/Mayport (HRS-2 SEAST).

3. Option 3 – Coastal

In option 3, all training for a specific T/M/S is located in a single squadron. The four geographic combinations consist of locating each different T/M/S FRS at a single site: one SH-60R FRS squadron (HR WEST) at NASNI and one CH-60S squadron (HS NEAST) FRS at NAS Norfolk, one SH-60R FRS squadron (HR WEST) at NASNI and one CH-60S FRS squadron (HS SEAST) at NAS Jax/Mayport, one CH-60S FRS squadron (HS WEST) and one SH-60R FRS squadron (HR WEST) at NASNI, and one CH-60S FRS squadron (HS WEST) at NASNI and one SH-60R FRS squadron (HR SEAST) at NAS Jax/Mayport.

4. Option 4 – Mono

Option 4, offers the most significant departure from the current FRS organization. In this option, all FRS training, including both T/M/S, is located at a single site. The three geographic variants are: HRS WEST at NASNI, HRS NEAST at NORVA, and HRS SEAST at NAS JAX/MYPT.

C. DESCRIPTION OF TRAINING PLANS

Each of the options described previously is further broken out into one of two training plans (illustrated in Figure 3) that specify the training syllabus the student pilot will experience during his or her FRS training.

1. Plan A: Status Quo

In Plan A, the status quo training method, student pilots train in their ultimate fleet specific aircraft for the entire FRS syllabus. This applies to both flying and simulator events.

2. Plan B: Common Cockpit Syllabus Training

In Plan B, the portion of the FRS syllabus that is common to both the SH-60R and CH-60S aircraft is taught in the CH-60S regardless of the specific T/M/S the pilot will fly in their fleet specific squadrons. This training includes all flight events up through a student pilot's NATOPS qualification. Upon completion of the common cockpit portion of the FRS syllabus, a student pilot will complete the remainder of the FRS syllabus (mission specific) in the T/M/S aircraft and simulators he or she will fly in the Fleet.

The reason for this is that it is generally recognized that the CH-60S is less expensive to fly than the SH-60R. If SH-60R pilots can get some training using the cheaper CH-60S, cost savings will be achieved.

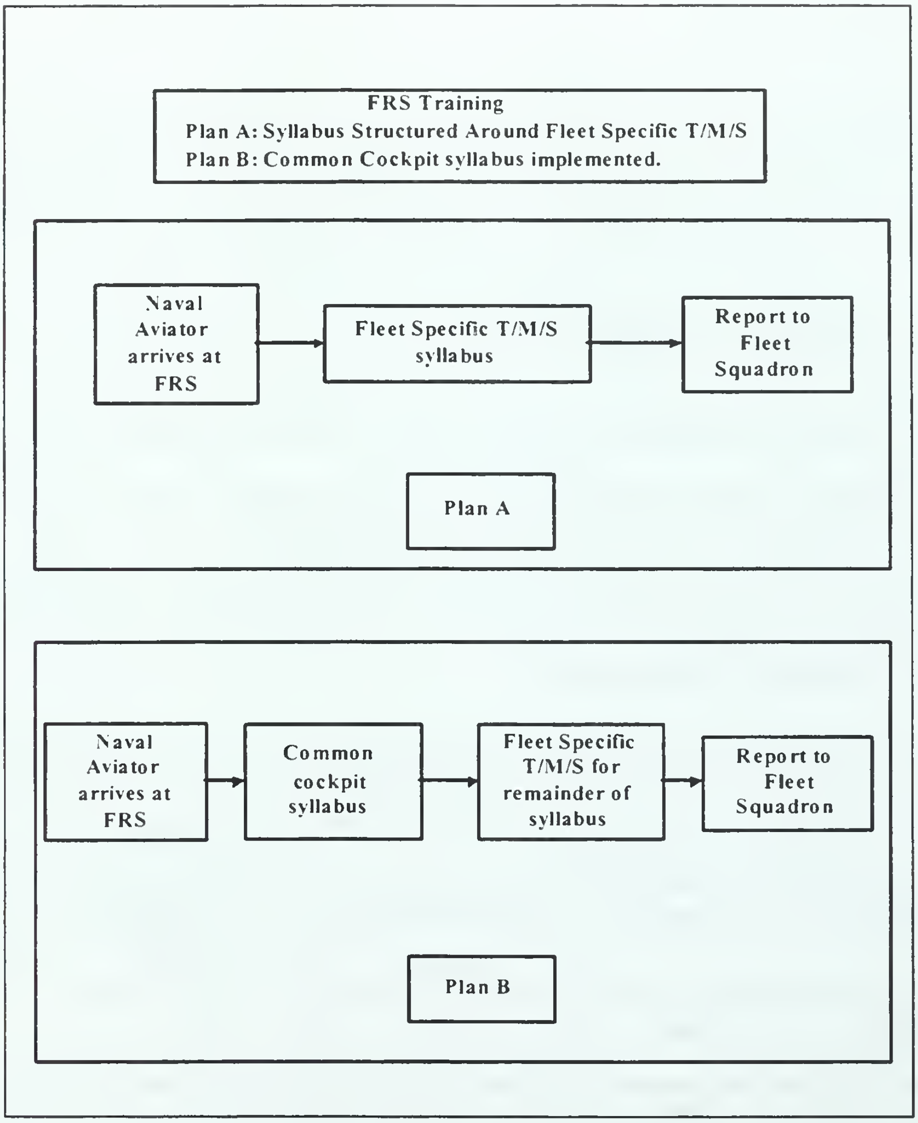

Figure 3: Illustration of Training Plans A and B. In training Plan A, the status quo training method, student pilots train in their ultimate fleet specific aircraft for the entire FRS syllabus. In training Plan B, student pilots are taught with a common cockpit syllabus. Upon completion of the common cockpit training, the student pilot completes the FRS training in their ultimate fleet specific aircraft.

D. ASSUMPTIONS

Development of these models requires some fundamental assumptions regarding student throughput and specific syllabus characteristics. These two areas are critical in the creation of any FRS composition and warrant sensitivity analysis (addressed later).

1. Student Throughput

The models use student throughput levels provided by N889 for fiscal year 2012 (FY12) (Mullarky, 2000). These levels are assumed to capture the CH-60S and SH-60R helicopter community after the transition has been made to the H-60 T/M/S and are shown in Table 2. The student requirements are listed according to the location of the aviator's ultimate fleet squadron location.

FY2012 Requirements				
		Annual Fills		
Aircraft	Coast	Junior Officer (CAT I)	Dept. Head (CAT III)	XO (CAT IV)
SH-60R	East	66	26	6
SH-60R	West	60	29	6
CH-60S	East	57	20	6
CH-60S	West	68	16	6

Table 2: Projected FY12 Student Requirements By Fleet Squadron. The projected student throughput is organized according to the Category of training the student pilot requires and the coast on which the student pilot's ultimate fleet quadroon is located.

2. Syllabus Characteristics

Certain syllabus characteristics are specified due to policy and doctrine; these include the number of training days per year, aircraft workday (hours/day), instructor workday (hours/day), and instructor availability. Originally specified by the Chief of Naval Aviation Training (CNATRA) these parameters are Department of the Navy standard for helicopter training. The calculations for each of these fixed syllabus assumptions is detailed in Appendix B and their specific values are listed in Table 3.

Fixed Syllabus Characteristics	
Assumption	**FRS**
Training-Day/Yr	**228 Days**
Aircraft Workday	**12 Hrs/Day**
Instructor Workday	**8 Hrs/Day**
Instructor Availability	**66%**

Table 3: Fixed Syllabus Characteristics. These characteristics are specified by U.S. Navy instructions. They are considered Department of the Navy standard for helicopter training.

The initial cadre of instructor pilots will train under the CH-60S syllabus. This syllabus, consisting only of CAT I and CAT II training, is still in development. The SH-60R syllabus is also in development. The SH-60R and the common cockpit syllabus details were determined by the H-60 FIT using the most recent training requirements identified for the SH-60R. Accordingly, the syllabus specifics for the CAT III and CAT IV pilots in both the CH-60S and SH-60R syllabi were calculated using the 70% and 50% metrics of the CAT I syllabi respectively. These syllabi were based on previous syllabi for the SH-60B/F. In the projected common cockpit syllabus, the SH-60R does not

require any simulator events during the aircraft qualification phase of the training. While the syllabi for the SH-60R and CH-60S are constant, they differ in the number of flight events and simulator events between T/M/S.

The attrition rate was held constant at 3.5% for CAT I and 0.0% for CAT III and higher. The attrition rate affects load planning and input requirements. It is assumed that attrition occurs midway through training. For each squadron, the following overhead classifications were included: Incomplete/Abort Flights, Refly events, Instructor Under Training (IUT) flights, Functional Check flights (FCF)/Test, Service flights, Transit flights, Logistics flights, and Stash/Stan flights. These values were determined using FRS specific rates, based on historic data, and approved by OPNAV.

3. Fleet Squadron Locations

The reorganization of the helicopter community according to the HMP will also result in a reorganization of the Fleet Squadrons. The determination of the future Fleet Squadron locations and designations is still under discussion. For the purposes of this study, the Fleet Squadrons have been viewed as remaining in the mission concentration areas of the current configuration. Figure 4 depicts a projected Fleet Organization used in this study (Mullarky, 2000). The proximity of the FRS's to the fleet squadrons will have an impact on the number of student pilots that will have to transfer cross-country or within the East coast upon completion of training.

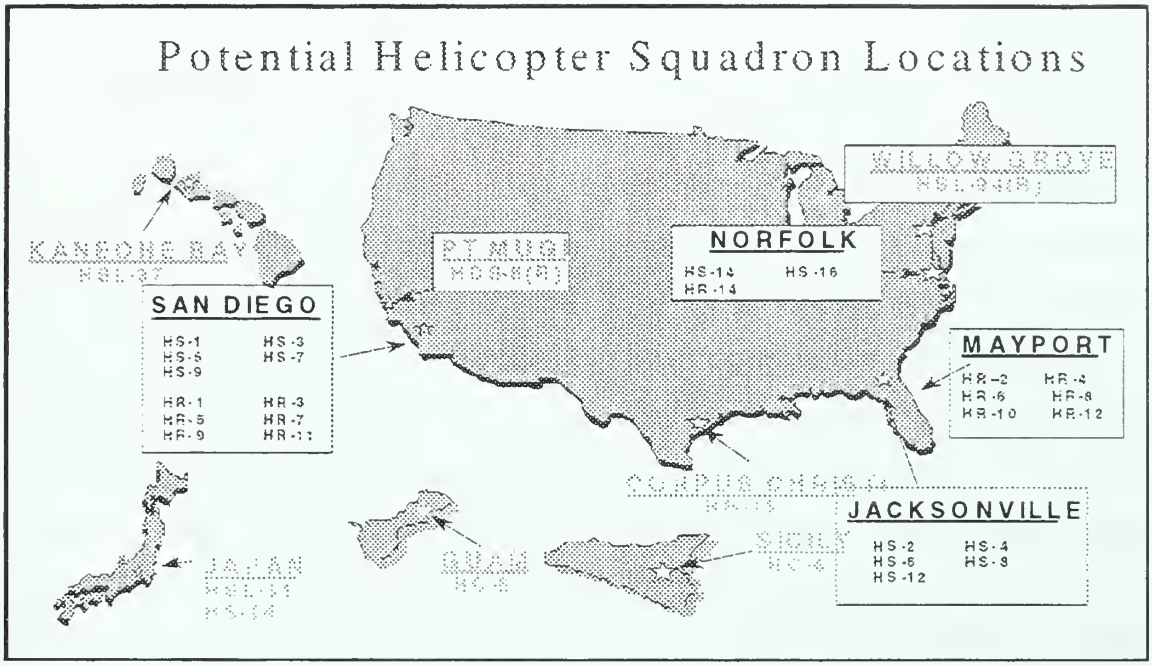

Figure 4: After Ref. 7, Potential Organization for Future U.S. Navy Helicopter Squadron Locations. The fleet concentration locations remain in their current areas. However, the squadron designations are changed to reflect the new aircraft and the new organization of mission areas.

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III. COST ANALYSIS

A. BACKGROUND

Cost data for the organizational options is gathered into two categories: procurement costs and 20 years of annual training costs. Procurement costs consider the cost involved with the actual procurement of new aircraft, hangars, and simulators required for each alternative. Annual training costs represent the cost of the people required for each alternative (instructor pilots, maintenance, supply, and administrative personnel), and the cost of training the projected FY2012 student throughput. The cost of a Permanent Change of Station (PCS) transfer is also included in annual training costs. This cost is incurred in alternatives wherein a student pilot is required to transfer greater than 50 miles upon completion of training. The cost of transferring a student pilot with dependents is greater than that of a student pilot without.

B. PROCUREMENT COSTS

1. Unit Procurement Costs

The number of aircraft required for each alternative was determined using the Naval Aviation Production Planning Improvement (NAPPI) Production Planning Factor (PPF) model. The PPFs are used as a standardized planning tool for annual instructor, aircraft, simulator and flight hour requirements. The model is described in detail in Appendix A. Variation in the number of aircraft required for each alternative are due largely as a result in variations of a few of the input characteristics to the NAPPI model: syllabus length, student throughput, the number of sorties requiring Fully Mission capable (FMC) aircraft and Mission Capable (MC) aircraft, and historic FMC and MC rates (an indication of maintenance reliability).

The unit costs for the SH-60R and CH-60S provided by the H-60R/S Fleet Introduction Team (FIT), are approximately $30.0M and $16.2M, respectively (Mullarky, 2000).

It is significant to note that the procurement portion of this study has the greatest impact on the total cost. Subtle changes to the input characteristics previously mentioned have the potential to impact the number of aircraft and simulators required for a given option. A change to the number of aircraft required can further impact the infrastructure necessary for implementation of an alternative. The total number of aircraft, simulators, and hangars required for each option is listed in Appendix B.

2. Hangar Availability

According to the Naval Facilities Planning Document (NAVFAC P-80), the number of aircraft that will be in the hangar at one time is one third of the average number of aircraft in the squadron. A hangar is not designed to hold all aircraft, all of the time. Hangars are considered necessary for maintenance only; i.e. not for stowage of helicopters. As a result, the majority of the helicopters are stored outside the hangar, which subjects them to increased wear and tear due to the elements.

NAS Norfolk has a one for one construction/destruction planned (FY01 and FY04). A WWII hangar, which currently houses HC-2, is planned for demolition. In its place will be constructed a smaller Type I hangar. Current plans are for HC-2 to share the new hangar with HCS-4 (a reserve squadron with 11 aircraft assigned). As a result, HC-2 will possess approximately half of the hangar for their use. There will be space available next to the newly constructed hangar P526. However no construction is planned.

Currently, NAS Mayport fully utilizes all available hangar space, including infrastructure for a reserve squadron recently established. There is a potential location for a new construction hangar, however no new construction is planned.

NAS Jacksonville was the former location of a now disestablished HS FRS (HS-1). The hangar space is readily available to house an FRS should the need arise. No new construction is planned.

NAS North Island is currently at capacity with respect to its hangar space utilization. Currently, no new construction is planned.

The total amount of additional infrastructure required for each option is listed in Appendix B.

3. Simulator Availability

The simulator plan for FY12 is expected to be a modification of the existing simulator structures. Accordingly, NAS North Island will have 3 SH-60R simulators and 3 CH-60S simulators, NAS Mayport will house 3 SH-60R simulators, and NAS Jax will house 2 CH-60S simulators. NAS Norfolk will have 1 CH-60S simulator.

The procurement cost for both the SH-60R and the CH-60S simulators is $25M. This cost includes the "back end" modification required to install equipment to handle the training requirements for the OAMCM and CSAR missions.

4. Procurement Cost Results

Total procurement costs are shown in Figure 5. Quad alternative 2B and Pair alternative 2B had the lowest procurement cost at $1387M ($FY01). These two alternatives consider common cockpit training at NASNI and NAS JAX/MYPT. Alternative Quad 2B consists of two specific FRS's in each location while alternative Pair 2B consists of a combined FRS in each location. These two alternatives use the most of the existing hangars and simulators, and require the least amount of infrastructure procurement. In every case it is less expensive to use the common cockpit approach to training because of the requirement to procure more of the less expensive CH-60S aircraft.

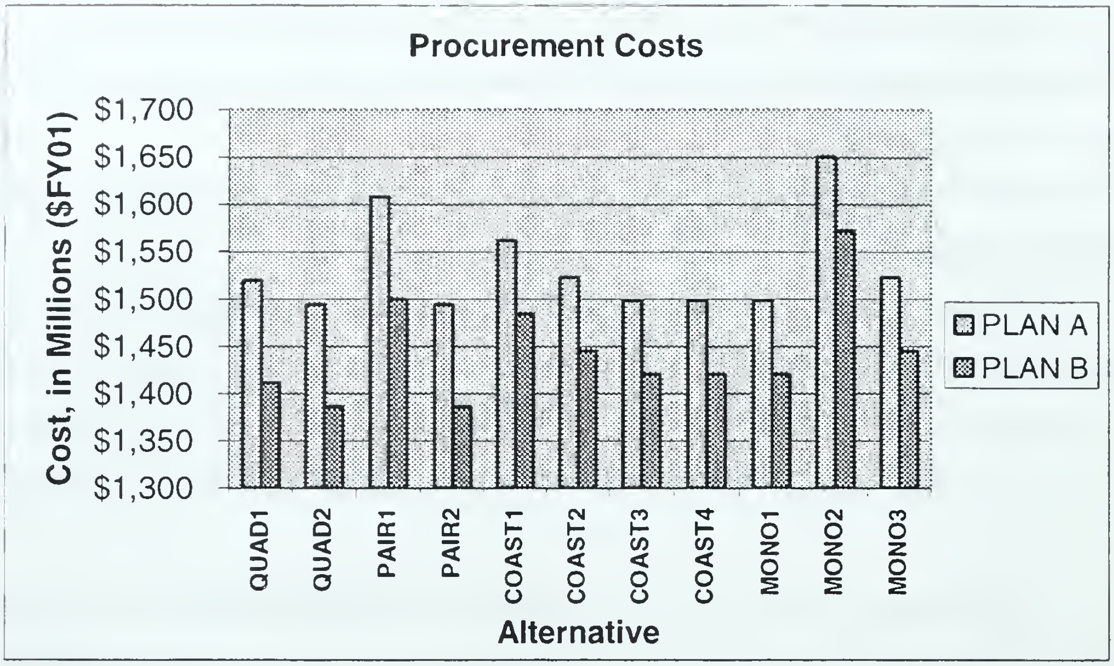

Figure 5: Aircraft Procurement Costs, FY01$. Alternatives Quad2B and Pair 2B have the lowest procurement cost at a value of $1387M. Both of these alternatives use common cockpit training at NASNI and NAS JAX/MYPT.

C. ANNUAL TRAINING COSTS

1. Cost Per Flight Hour

The annual training cost for each alternative is the cost per flight hour times the number of flight hours required by the syllabus for that alternative.

The cost per flight hour is an extremely important value calculated in this cost analysis. Naturally, these values vary among different aircraft. The estimates used were determined using the Navy VAMOSC data from FY92 through FY97 (Naval Center for Cost Analysis, 1998; Hoeft, 1999). VAMOSC is organized into six mutually exclusive cost categories as specified below:

1.0 **Organizational Costs:** Those costs that are attributable to organizational level operations and maintenance support of regular operating aircraft.

2.0 **Intermediate Costs:** Those costs attributable to intermediate level operations and maintenance support.

3.0 **Depot Support Costs:** Those costs attributable to organic depot level maintenance activities and by commercial depot organizations.

4.0 **Training Support Costs:** Includes organizational costs of Fleet Readiness Squadrons, maintenance training, and specialty training.

5.0 **Recurring Investment Costs:** The cost of recurring investment items directly attributable to the various T/M/S. This includes the annual cost of purchases for modification kits and spares required for specific T/M/S aircraft.

6.0 **Other Functions:** These are costs directly attributable to an aircraft T/M/S but not included elsewhere in the report. These include engineering or technical services support and costs of updating publications.

Using historical data, six years worth of operating and support costs were calculated; the total was then divided by the total number of flight hours flown by that type of aircraft in that six-year period. The resulting values represent the average cost per flight hour of that specific T/M/S for that six-year period.

The cost per flight hour for the SH-60R and CH-60S were calculated using historical data from the SH-60B and the HH-60H respectively. The aircraft were chosen due to similarities in airframe, components, avionics, and mission. The cost per flight hour is provided in Table 4.

Type Aircraft	VAMOSC '92 – '97 (CY01$)
SH-60R	$4089
CH-60S	$3880

Table 4: VAMOSC '92-'97 Costs per Flight Hour for the SH-60R and CH-60S Helicopters. The values were determined using the VAMOSC database for the similar aircraft.

A histogram of the expected annual training costs of each alternative is provided in Figure 6. Due to the fact that the student syllabus is fixed, the number of flight hours required in each alternative is constant, regardless of geographic location or squadron configuration. However, it is clear that training Plan A is more expensive than Plan B whenever implemented, because the operating cost of the CH-60S is less than that of the SH-60R.

2. Permanent Change of Station (PCS) Costs

There is a cost incurred for each permanent change of station (PCS) move a student pilot makes, should he or she complete FRS training at a command in a different geographic location from his or her ultimate fleet squadron. The cost of a PCS move is estimated by the Bureau of Personnel (BUPERS) Code 454, Distribution, Management, Allocation, Resources and Procedures Division – Fiscal Management Branch. There is a higher cost for a move across the country compared to a move within the same coast. Additionally, the cost differs depending on the dependent status of the student pilot. The cost of 20 years of PCS moves was estimated for each alternative depending on the number of cross country or intra coast transfers required. It was assumed that 75% of the pilots would have dependents.

3. Annual Training Cost Results

Quad alternative 2B has the lowest annual training cost of $2461M ($FY01) as depicted in Figure 6. Quad alternative 1B is a close second with an annual training cost of $2463M ($FY01). These two alternatives differ only by $2M ($FY01).

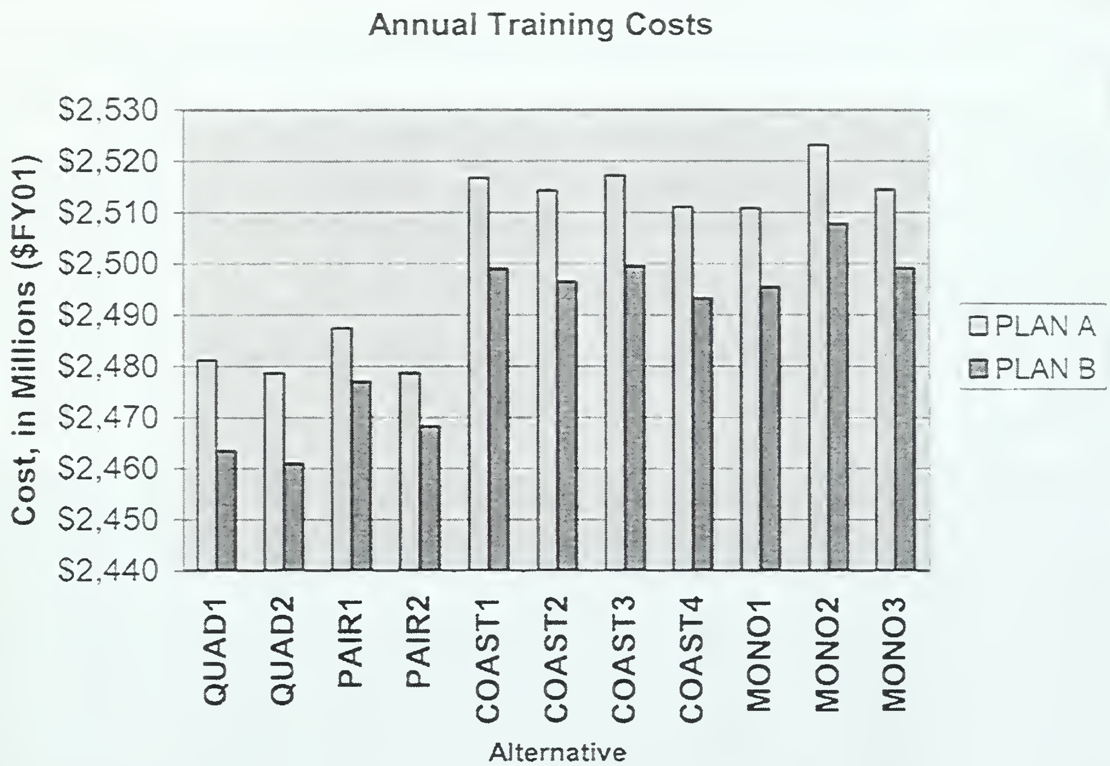

Figure 6: Annual Training Costs for Each Alternative. FY01\$. Alternative Quad2B has the lowest annual training cost of \$2461M. Alternative Quad1B is a close second with a annual training cost of \$2463M. These two alternatives differ by only \$2M.

D. TOTAL COSTS

The total costs of alternatives were estimated for the next 20 years (see Figure 7). If cost were the only concern, the alternative with the lowest total cost would be preferred. A group of three alternatives, Quad 2B, Pair 2B, and Quad 1B have the lowest total cost. These options all consider configurations in which FRS training is located on both coasts with separate FRS per T/M/S. Alternative Quad 2B has the lowest total cost of \$3848M (FY01\$). However, alternative Pair 2B has a cost of \$3855M (FY01\$); a total cost that only differs by approximately \$7M. This cost increase is due to alternative

Pair 2B's slightly higher requirement of SH-60R flying hours. Additionally, the third least expensive alternative, alternative Quad 1B has a total cost of $3875 (FY01$M). This increase is due to the need to procure an additional CH-60S simulator for NORVA.

The total cost of many of the alternatives differs within the cost of an additional simulator or a relatively small amount of flying hours in a specific aircraft. The selection of the best alternative, therefore, should be based upon a combination of the total cost and the attributes for each option.

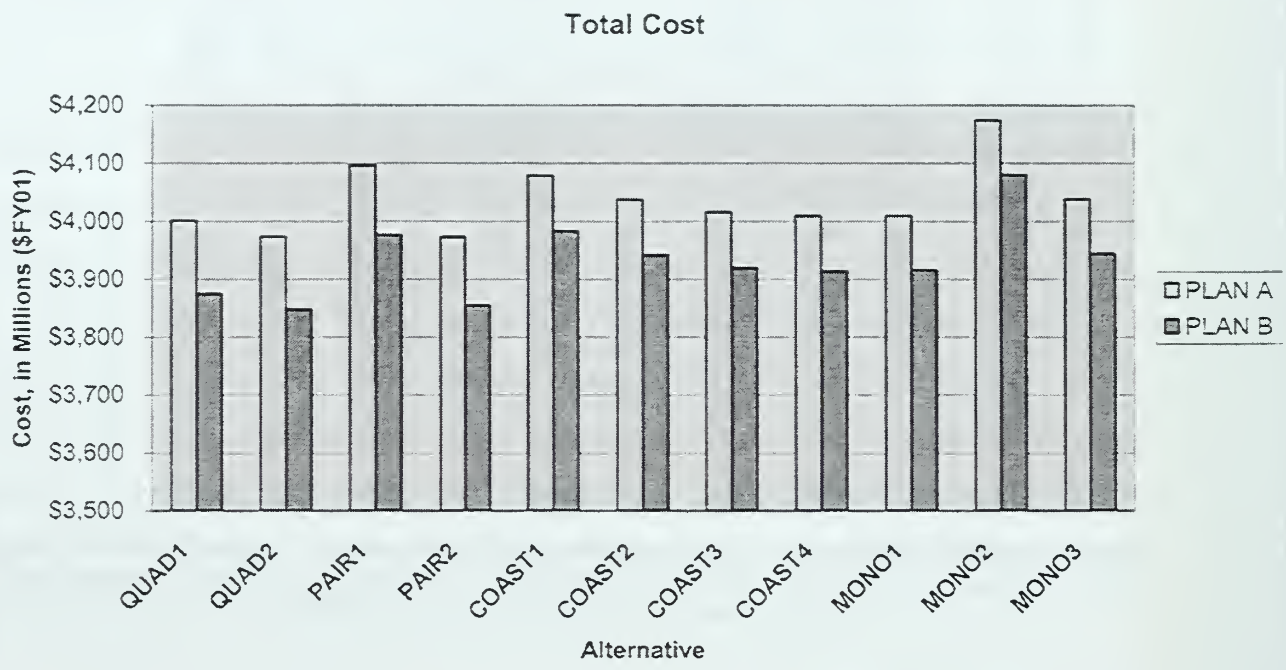

Figure 7: Total Cost for Alternatives, FY01$. Alternative Quad 2B has the lowest total cost of $3848M. Alternative Pair 2B has the second lowest total cost of $3855M. These two alternatives differ only by $2M. The selection of the best alternative should be based upon a combination of the total cost and the attributes for each option.

IV. ANALYSIS OF NON-MONETARY ATTRIBUTES

A. METHODOLOGY

The attributes studied are the expected, non-monetary yields from an investment of resources. These attributes can be positive or negative, and may be either qualitative or quantitative.

The attributes selected for analysis are items which all have a significant impact on providing quality training to the student pilot in the FRS. Following is an analysis of the five attributes: the number of squadrons disestablished, the number of squadrons established, officer-to-enlisted ratio, the number of PCS moves required, and the total flight hours per month per aircraft.

B. DEFINITION OF ATTRIBUTES

1. Number of Squadrons Established/Disestablished

The number of squadrons established and/or disestablished for each organizational alternative is an indicator of the level of difficulty required to implement the alternative. The challenge associated with integrating a new helicopter community centered on a new aircraft is present in all of the alternatives to some degree. In addition to the impact on the surrounding community and environment, there is also the effort associated with the logistics of moving people, supplies, and equipment.

The scores for this attribute, listed in Table 5, reflect the raw number of squadrons established and/or disestablished for each alternative. If an existing squadron was replaced with a squadron of similar size and structure in the same location, this received a score of 0; i.e. the change would only involve the arrival of items due to the new aircraft; an impact that will be felt by all squadrons regardless of location and size. If a squadron of a size that would require more than just a change of the command name replaced an existing squadron, this received a score of 1. A smaller score would indicate more use of

the existing infrastructure and less change to the organization from what currently exists at the specified location.

In this attribute, the unique case of HC-2 in NORVA is addressed as follows: if an option involved the disestablishing of HC-2, this received a score of 0.25 since it would involve disestablishing the quarter of HC-2 responsible for the FRS training. Conversely, for the options in which NORVA was selected to site a single, conventional sized FRS squadron (i.e. the smallest squadron size addressed in this study), this was counted as requiring the establishment of a partial squadron (a factor of 0.75).

OPTION	Total Cost (FY01$M)	Number of Squadrons Disest	Number of Squadrons Est	Officer-to-Enlisted Ratio	PCS Moves	Util Rates
QUAD1A	$4,001	0.00	0.75	5.36	67	39.82
QUAD1B	$3,875	0.00	0.75	5.34	67	38.94
QUAD2A	$3,973	0.25	1.00	5.36	36	39.82
QUAD2B	$3,848	0.25	1.00	5.34	36	38.94
PAIR1A	$4,096	3.25	2.00	5.29	145	39.82
PAIR1B	$3,977	3.25	2.00	5.29	145	39.65
PAIR2A	$3,973	3.25	2.00	5.29	36	39.82
PAIR2B	$3,855	3.25	2.00	5.29	36	39.65
COAST1A	$4,079	3.25	2.00	5.19	245	41.10
COAST1B	$3,983	3.25	2.00	5.19	245	39.34
COAST2A	$4,038	3.25	2.00	5.19	214	41.10
COAST2B	$3,942	3.25	2.00	5.13	214	39.34
COAST3A	$4,016	3.25	2.00	5.19	266	41.10
COAST3B	$3,920	3.25	2.00	5.13	266	39.34
COAST4A	$4,009	3.25	2.00	5.19	188	41.10
COAST4B	$3,914	3.25	2.00	5.19	188	39.34
MONO1A	$4,009	3.25	1.00	5.57	181	41.10
MONO1B	$3,916	3.25	1.00	5.57	181	40.03
MONO2A	$4,174	3.25	1.00	5.57	330	41.10
MONO2B	$4,080	3.25	1.00	5.57	330	40.03
MONO3A	$4,038	3.25	1.00	5.57	221	41.10
MONO3B	$3,945	3.25	1.00	5.57	221	40.03
BEST	**$3,848**	**0.00**	**0.75**	**5.13**	**36.00**	**38.94**

Table 5: Raw Attribute Scores for Each Alternative. A raw score is listed for each alternative for each attribute category. The best or most preferred scores are listed at the bottom. The alternative with the best raw score in an attribute category is highlighted. Total cost is included for reference.

2. Officer-To-Enlisted Ratio

As each alternative changes in size, so does the manpower required to operate and support it. In addition to the instructor pilots, there are various maintenance and support personnel required to keep the aircraft operational, administer personnel issues and ensure that the supply structure is working.

A manpower study to specifically investigate the personnel required to support the H-60R/S FRS is planned for FY2002. Currently, there is no information on the manpower changes required for the new T/M/S. The manpower estimates used here are based on current squadrons, and consist of a range of personnel. These ranges were derived from Naval Manpower Command (NAVMAC) estimates and guidelines, and are not considered official manpower requirements. From these ranges, an estimated officer-to-enlisted ratio was calculated. The officer-to-enlisted ratio, listed in Table 5, captures the span of control per alternative. A lower value is preferred, indicating a tighter chain of command.

3. Number of Permanent Change of Station (PCS) Moves Required

Upon completion of training at the FRS, a student pilot will require a transfer to his or her ultimate Fleet Squadron. This transfer can involve a move across the country (or ocean), or a move across the street. Most service members prefer to minimize the number of moves on their families and property. Additionally, a local move involves fewer expenses in time and money than a cross-country transfer.

The number of moves a student pilot makes as a result of his or her training pipeline varies depending on the location of the pilot's Fleet Squadron assignment. A score is assigned depending on the number of PCS moves required, the location of the FRS, the location of the ultimate Fleet Squadron (depicted in Figure 4), and the number of SH-60R or CH-60S pilots required in each Fleet Squadron location.

A smaller score is preferred indicating the fewest number of student pilots requiring transfer upon completion of their training (see Table 5).

4. Flight Hours per Month per Aircraft

The number of flight hours conducted on each aircraft per month indicates the load placed on each aircraft. Additionally, it is an indicator of the flying time each squadron will be required to meet for the month's training obligations. The utility rate per Month per Aircraft may also be a sign of the impact on the surrounding airspace.

The number of SH-60R or CH-60S flight hours varies among alternatives depending on the number of each T/M/S required and the number of squadrons involved. A smaller utility rate is preferred, indicating less stress on the aircraft, and a less dense flight schedule (see Table 5).

The raw scores in Table 5 point out a few interesting results. In considering attributes alone, Quad Option1 is preferred in the majority of the attribute categories. Pair Option 2 and Coastal Option 3 are referred in the attribute of PCS Moves and Manpower, respectively.

V. SCORING AND SELECTION OF ALTERNATIVES

A. ADDITIVE WEIGHTING AND SCALING MODEL

1. Definition

The method applied to this problem is additive weighting and scaling (Army Logistics Management College, 1996). This method allows the decision-maker to weigh the attributes as he or she deems appropriate and determines a cost/attribute ratio for each alternative.

A major attractive feature of this model is its simplicity. The attributes are scaled in such a manner that seemingly incomparable units become comparable.

2. Application

Let the 22 alternatives be represented by the subscript $j = 1,2 \ldots 22$. Let the five attribute categories be represented by $k = 1 \ldots 5$. Let the raw score of a given attribute be indicated by r. Therefore, $r_{j,k}$ indicates the raw score of the j^{th} alternative for the k^{th} attribute. Further, let $r_{k,\,best}$ indicate the best score for attribute k. Note that the best score does not necessarily mean the largest score. If a small value were preferred, then the best score would be the smallest, and vice versa. The raw scores for each attribute and alternative are scaled as follows:

If a high number is preferred in the raw score, then the following formula is applied to scale the data:

$$S_{j,k} = \frac{r_{j,k}}{r_{kbest}}$$

where $S_{j,k}$ = the scaled value of attribute k in alternative j

$r_{j,k}$ = the raw score

r_{kbest} = the "best" score of attribute k over all alternatives

If a low number is preferred in the raw score, then the following formula is applied to scale the data:

$$S_{j,k} = \frac{r_{kbest}}{r_{j,k}}$$

where $S_{j,k}$ = the scaled value of attribute k in alternative j

$r_{j,k}$ = the raw score

r_{kbest} = the "best" score of attribute k over all alternatives

These scaled scores now provide a number between zero and one for each attribute under each alternative. The alternative with the best raw score for a given attribute has a scaled score of 1 in that attribute. Let the weight assigned to attribute k be denoted w_k. The weighted score of attribute k in alternative j is

$$WS_{j,k} = S_{j,k} * w_k$$

Let the overall attribute score for alternative j be denoted B_j. Then

$$B_j = \sum_k WS_{j,k}$$

The decision-maker may now draw conclusions based upon attributes alone. If attributes were the only consideration, the alternative with the largest overall attribute score would be the preferred alternative.

The cost-attribute ratio is obtained for a given alternative by dividing the respective total cost by the respective overall attribute score determined above. Let V_j represent the total cost of alternative j. Then the cost-attribute ratio would be calculated as follows:

$$(Cost - Attribute\,Ratio)_j = \frac{V_j}{B_j}$$

Since a small cost and large attribute score are preferred, a small cost-attribute ratio is desired.

B. RESULTS

The scaled attribute scores are given in Table 6. The options were evaluated from three different perspectives. First the raw, unweighted attribute score was determined for each alternative. These scores were then compared against each other. Coast alternatives 1, 4, and all Mono alternatives were dominated when considering lowest total cost and in each attribute category. These alternatives remained in consideration to provide the decision maker with results for all specified alternatives. Next, each attribute category was separately evaluated as if it was the most important attribute category. For example, if the number of squadrons to be disestablished was determined to be the most important attribute, it received a weight of 100%; the remaining categories received no weight. Finally, weight was allowed to vary according to a discrete distribution containing weight values from 0% to 100%, in intervals of 10%. Each weight was given an equal probability of being applied. The weights were then normalized. This distribution was applied to each attribute category's weight score. 5000 Monte Carlo simulations were then conducted on the model with all five attributes receiving a varying weight. The mean and standard deviation of the Cost Attribute Ratio (CAR) of each alternative was determined, in addition to a range of possible outcomes. The resulting plot enables a decision-maker to see the CAR mean value of each alternative with weight varying. The range of possible outcomes illustrated how sensitive each alternative's CAR is to the varying ways a decision-maker can weight each category. An alternative with a narrow range can be viewed as having less risk to its mean than an alternative with a wider range. In some cases, an alternative may have a higher mean value but tighter range than an

alternative with a lower (more preferred) mean value, but a wider range. The former involves more certainty, while the latter includes values far higher than the highest high of the former score.

OPTION	Total Cost (FY01$M)	No. of Squadrons Disest	No. of Squadrons Est	Officer-to-Enlisted Ratio	PCS Moves	Util Rates	CAR
QUAD1A	$4.001	1.000	1.000	0.957	0.537	0.9777	895
QUAD1B	$3.875	1.000	1.000	0.961	0.537	1.0000	862
QUAD2A	$3.973	0.800	0.875	0.957	1.000	0.9777	862
QUAD2B	$3.848	0.800	0.875	0.961	1.000	1.0000	830
PAIR1A	$4.096	0.235	0.583	0.970	0.248	0.9777	1359
PAIR1B	$3.977	0.235	0.583	0.970	0.248	0.9820	1317
PAIR2A	$3.973	0.235	0.583	0.970	1.000	0.9777	1055
PAIR2B	$3.855	0.235	0.583	0.970	1.000	0.9820	1022
COAST1A	$4.079	0.235	0.583	0.987	0.147	0.9473	1406
COAST1B	$3.983	0.235	0.583	0.987	0.147	0.9898	1354
COAST2A	$4.038	0.235	0.583	0.987	0.168	0.9473	1382
COAST2B	$3.942	0.235	0.583	1.000	0.168	0.9898	1324
COAST3A	$4.016	0.235	0.583	0.987	0.135	0.9473	1390
COAST3B	$3.920	0.235	0.583	1.000	0.135	0.9898	1332
COAST4A	$4.009	0.235	0.583	0.987	0.191	0.9473	1362
COAST4B	$3.914	0.235	0.583	0.987	0.191	0.9898	1310
MONO1A	$4.009	0.235	0.875	0.920	0.199	0.9473	1262
MONO1B	$3.916	0.235	0.875	0.920	0.199	0.9726	1223
MONO2A	$4.174	0.235	0.875	0.920	0.109	0.9473	1352
MONO2B	$4.080	0.235	0.875	0.920	0.109	0.9726	1311
MONO3A	$4.038	0.235	0.875	0.920	0.163	0.9473	1286
MONO3B	$3.945	0.235	0.875	0.920	0.163	0.9726	1246

Table 6: Scoring and Selection of Alternatives. Unweighted Cost Attribute Ratio Scores. Quad Option 1 alternatives receive the most favorable scores in the majority of the categories. The exception is Pair alternative 2A and 2B in the PCS Move attribute category and Coast alternative 2B and 3B with respect to the Officer-to-Enlisted Ratio. In the former, Quad Option 1 alternatives share the best CAR score with alternative Pair 2A and 2B. In the latter attribute category, Coast alternatives 2B and 3B have the most preferred CAR score.

1. Attribute Score (Raw Score Without Weight Applied)

Overall, Quad Option 1 was highly ranked when only looking at the raw attribute scores of each alternative, displayed in Table 6. The alternatives in Quad Option 1 included the alternative with the lowest total cost, Quad alternative 2B.

The alternatives in Quad Option 1 with east coast HS training located in NORVA and east coast HR training located in NAS JAX/MYPT (Quad alternative 1A and 1B) were preferred in both the number of squadrons established and number of squadrons disestablished. Closely ranked was a similar option with all east coast training located in NAS JAX/MYPT (Quad alternative 2A and 2B). These locations make the most use of existing squadrons.

In the PCS Moves category, Quad alternative 2A and 2B came out on top tied with Pair alternative 2A and 2B (combined HR and HS training on each coast). These alternatives take advantage of the locations of the Fleet Squadrons. By having training available on each coast, student pilots are not required to PCS across the country to reach their ultimate fleet squadron. The need to PCS on the East Coast from NAS JAX/MYPT to NORVA remains.

Regarding utility rates, Quad Option 1 alternatives, using the common cockpit syllabus, come out with the best score. In these alternatives, flying hours are the most spread out among squadrons and number of aircraft required. The utility rate differences for all of the alternatives do not vary greatly. The attribute scores clearly illustrated that Quad Option 1 utility rates are preferred.

Coast Option 2B and 3B achieved the best attribute score with respect to the officer-to-enlisted ratio. However, the scores in this category did not vary much. It is expected that more specific manpower contributions will be available in the future and provided more succinct results.

2. Individually Weighted Attribute Scores

In the case where the number of squadrons disestablished was selected as the most important attribute category, Quad alternative 1B had the best cost-attribute ratio. Both Quad alternative 1B and 1A have the best score achieved in this attribute category, however Quad alternative 1B has a lower total cost than Quad alternative 1A and would therefore be the preferred option. Both alternatives consider two separate FRS's on each

coast with the HS training located in NORVA. The alternatives differ in the selection of the training plan implemented.

Quad Option 2B in which the HS training is located in NAS JAX/MYPT instead of NORVA, is a very close second. This option has a higher CAR due to the fact it requires that the small FRS in NORVA be disestablished.

Similarly, when considering the number of squadrons established as the most important attribute, the same alternatives earn the same relative ranking. Quad alternatives 1A and 1B require only that the small FRS in NORVA become a stand alone FRS. Quad Alternatives 2A and 2B require the establishment of a complete FRS in NAS JAX/MYPT.

When the officer-to-enlisted ratio attribute category receives 100% weight, Coast alternative 3B receives the highest score. The difference between this alternative and the remaining alternatives is not substantial. This alternative has the smallest officer-to-enlisted ratio.

Regarding PCS moves, Quad alternatives 2A, 2B, and Pair alternatives 2A, and 2B are preferred in this category; their CARs are noticeably higher than the remaining alternatives by a significant amount. Both locations have FRS's located on both coasts, eliminating the need for cross-country transfers. Additionally, this option consists of FRS's located near fleet squadron concentrations (NASNI and NAS JAX/MYPT), reducing the need for intra-coast transfers within the East coast.

Considering utility rates, Quad alternative 2B achieves the best CAR. Throughout Quad Option 1, training Plan B requires more CH-60S to complete the syllabus. With more aircraft, one sees a lower utility rate. Combined with a lower operating and procurement cost, training Plan B results in a more preferential utility rate to training Plan A. Quad alternative 1B also has the top attribute score with respect to the utility rate attribute. While Quad alternative 1B involves three geographically different air stations, Quad alternative 2B involves two. This may result in less air space congestion per air station. However, Quad alternative 2B's lower total cost makes it the preferred alternative.

3. Weighted Attribute Simulation

Each decision-maker may choose to select a different attribute as the most significant from his or her perspective. A simulation that varies the combination of weights among all of the attribute categories was created. The result, seen in Figure 8, is a range that illustrates how sensitive the mean of each alternative's CAR score is to the different ways in which different decision-makes could evaluate the attributes.

The results of the weight attribute simulation break out three distinct groupings of alternatives. Group 1 ("most preferred"), consisting of Quad alternatives 1A, 1B, 2A, and 2B, breaks out as the clear favorite. These alternatives have the lowest mean and the tightest range. These options all involve multiple coast and T/M/S specific squadrons. Quad alternative 2B, has the overall lowest mean CAR and the overall tightest range. This means that a decision-maker can consider this alternative as less variable than the others. The preference for these alternatives is logical considering the majority of top scores received in the attribute categories involved Group 1 alternatives.

Group two ("next best"), consists of Pair alternatives 2A and 2B. These alternatives also have low mean values. These alternatives are similar to the options in Group 1 with the difference that the Group 2 alternatives involve combined squadrons. The mean values for this group are higher than the highest highs of Group 1. The lowest lows for Group 2 are still higher that the means of alternatives 1A and 1B, and higher than the highest highs of alternatives 2A and 2B.

Group three consists of the remainder of the alternatives ("not recommended"). With the exception of Coast alternatives 2B and 3B, these alternatives have failed to reach the top score in any category. Coast Alternative 3B received the best score for the officer-to-enlisted ratio attribute alone. The lowest lows for these alternatives have CARs are still higher than the highest CAR values of Group 1 and higher than the means of Group 2.

The groupings of the alternatives give the decision-maker an idea of the risk associated with the alternatives in each group. A decision-maker may decide to choose

an alternative in group 2 or group 3. However, these alternatives carry with them CARs that could result in a potentially undesirable CAR score. A decision-maker may be far more comfortable with selecting a Group 1 option, specifically Quad alternative 2B. The variability for this alternative carries with it far less of a risk due to varying attribute weights.

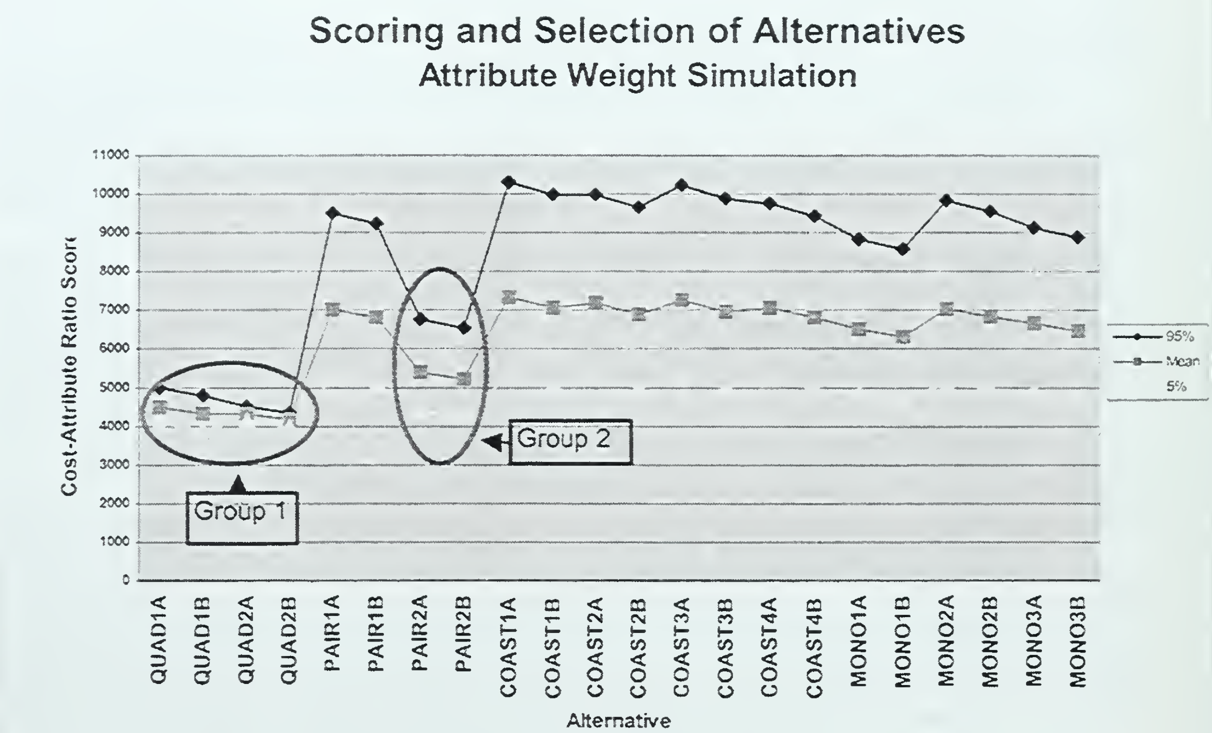

Figure 8: Selection of Alternatives - Cost Attribute Ratio. Attribute Weight Simulation. When weights are varied in a simulation, three distinct groupings of alternatives result. Group 1 consists of the most preferred alternatives. These alternatives have low CAR's and narrow ranges. Group 2 consists of two alternatives that are the next preferred choices. While not as tight as the Group 1 alternatives, these alternatives have low CAR's and narrow ranges. Group three consists of the remainder of alternatives. These alternatives are not preferred with respect to total cost and all attribute categories with the exception of Coast alternative 3B. Additionally, Group 3 alternatives have very wide CAR ranges. These alternatives involve a great deal of risk for the decision-maker.

VI. SENSITIVITY ANALYSIS

A. INTRODUCTION

The results of the model rely heavily on the accuracy of the input data. Sensitivity analysis is warranted to determine if slight changes in any of the inputs will alter the results. If a relatively small change in specific input data results in changes to the ranking of the alternatives, that input is considered "sensitive". Conversely, if specific input data may be altered freely without changing the resulting ranking of the alternatives, that input is considered "insensitive". As the CH-60S and SH-60R are delivered to the U.S. Navy, it is expected that certain input data, such as FMC/MC rates, cost per flight hour, and the procurement cost will change.

Inputs to the models may be broken down into three major categories: external, historical, and original. External inputs are those obtained from another organization or reference as factual. For example, procurement cost, determined by N889, is considered an external input. Historical inputs are obtained from analysis of historical data. Due to the nature of the aircraft at the center of this study, historical data does not exist. As a result, the historical data from the SH-60B and HH-60H T/M/S, analogous airframes, were utilized. While the airframes are analogous, they are not identical; therefore, sensitivity analysis is warranted in the area of cost per flight hour. An original area of data that warrants sensitivity analysis is FMC/MC rates due to their contribution in determining the number of aircraft, instructors, simulators, etc. required for each alternative. Both of these categories are expected to change as the CH-60S and SH-60R airframe arrive for operation in the FRS and Fleet Squadrons.

For each of the sensitivity attributes specified, a distribution was assigned. A simulation was conducted to determine the effect of varying these attributes, in addition to the attribute weight simulation, on the final CAR score. The resulting plot illustrated the likely value of each alternative's CAR score in addition to a corresponding range, given the varying sensitivity analysis attributes and a varying attribute weight.

B. SYLLABUS CHARACTERISTICS

1. Maintenance FMC/MC Rates

A Fully Mission Capable (FMC) helicopter has all systems and mission related equipment in full working order. An FMC helicopter is therefore able to conduct all missions that require an FMC helicopter. A Mission Capable (MC) helicopter is able to perform some, but not all of the missions specified for that aircraft. Syllabus flight events require either an FMC or MC aircraft. While MC events may be flown in an FMC aircraft, the converse is not true. The FMC and MC rates correspond to the probability that a given helicopter will be in an FMC or MC status.

The FMC/MC rates are significant contributors to determining the number of aircraft required for a given alternative. High maintenance rates reflect high readiness and aircraft availability, and thus a requirement for fewer aircraft to complete the given syllabus. Lower FMC/MC rates, however, require that fewer aircraft are available to meet the syllabus and student demands. The baseline values used for this thesis, specified by the H-60R/S FIT, were FMC rate of 50% and an MC rate of 70%.

It is possible that the new SH-60R and CH-60S will have maintenance rates that differ from the baseline values used. Historical rates for the SH-60B are 42.7% FMC and 57.5% MC. It is possible the SH-60R and CH-60S could have maintenance rates closer to these values. Or, perhaps, the newer T/M/S might have maintenance rate far better than the pervious variants. The Chief of Naval Operations (CNO) FMC/MC rate goals specify FMC and MC rates of 60% and 75% for the HH-60H and 58% and 77% for the SH-60B. To evaluate the effect of both of these extremes, FMC/MC rates +/- 10% of the baseline were considered.

The first range considered was the pessimistic case of an FMC rate of 40% and MC rate of 60%. Aircraft, hangar space and simulators required were affected by this change. The second range consisted of an FMC rate of 60% and MC rate of 80%. The aircraft requirement was determined for each squadron in each alternative given these two

extreme maintenance rates. A uniform distribution with these extreme values as the parameters was assigned to each aircraft requirement for each squadron independently.

C. COST PER FLIGHT HOUR

The cost per flight hour for each T/M/S was determined using the VAMOSC database for historical operating and support costs. The H-60 airframe, used to construct the SH-60R and the CH-60S is not a new airframe to the fleet. Additionally, given the revisions and redesigned of the H-60 in creating the SH-60R and CH-60S, it is possible that the operating and support costs will differ significantly from the historical airframes. On one extreme, it is possible that many lessons have been carried forward from experience with the SH-60B and HH-60H, resulting in a more efficient airframe, and thus a lower O&S cost per flight hour. It is also possible that the changes and new equipment on the SH-60R and CH-60S will result in a more expensive T/M/S due to parts availability or the increase in mission load to the H-60 airframe. A regression was run on the VAMOSC data considering cost per flight hour and year, and the standard error was determined. Increasing and decreasing the baseline cost per flight hour by the standard error selected a range for cost per flight hour for each aircraft (see Table 7). This range was used to assign a uniform distribution to the cost per flight hour for the SH-60R and the CH-60S. Operating and support cost were affected by this change.

Type Aircraft	VAMOSC '92 - '97 (FY01$)		
	-11.70%	Baseline	+11.70%
SH-60B	$ 3,609	$ 4,089	$ 4,569
HH-60H	$ 3,424	$ 3,880	$ 4,336

Table 7: Reduced, Baseline and Increased Cost Per Flight Hour. It is possible that the Cost to operate the SH-60R and the CH-60S will differ from the historical airframes. The baseline cost per flight hour was increased and decreased by the standard error resulting from a regression on the VAMOSC baseline data.

D. PROCUREMENT COST

The procurement cost of a new T/M/S has the potential for variation, especially as the procurement process approaches the delivery date. The unit procurement cost, specified by the program office could vary from the value specified for this study. The SH-60R has been discussed as potentially increasing in unit procurement cost. To evaluate the effect on an increased procurement cost, a higher value of $35M per aircraft was considered for the high limit for the sensitivity analysis for this attribute. On the other extreme, it should be noted that the SH-60R is actually a "remanufactured" SH-60B. A remanufactured aircraft is an airframe that has been refurbished, reengineered, and reworked so that it is both a new T/M/S and effectively "zeroed out" in the number of flight hours that specific airframe has flown. It is possible that the remanufactured SH-60B could reach the end of its service life before the SH-60R inventory is complete in the Fleet. An option in this situation would be to use an airframe already in the production line at Sikorsky Corporation. A suggested unit procurement cost for such an aircraft would be $25M. This value was considered as the lower end for the sensitivity value for this attribute. A triangular distribution with $30M as the most likely value and the aforementioned high and low unit procurement costs was assigned to the SH-60R procurement cost.

D. SENSITIVTY ANALYSIS CONCLUSIONS

1. Cost Attribute Ratio Score

Sensitivity analysis of FMC/MC rates, cost per flight hour, and procurement cost and the resulting impact on the Cost Attribute Ratio is depicted in Figure 9. This graph illustrates that, with respect to the CAR score, the ranking of the alternatives do not dramatically change with considerable variation to these inputs. The groups determined in the selection of alternatives remain intact.

The range surrounding Quad alternative 2B, the most preferred of Group 1, is not as tight when the sensitivity analysis attributes are varied. However, it does remain as the lowest and least risky alternative of Group 1 and of the remainder of the alternatives. Generally, as the alternatives involve bigger squadrons with larger requirements, the simulation of the sensitivity analysis attributes results in ranges with riskier outcomes. The exceptions are Pair alternatives 1A and 1B from Group 3. These two alternatives consider an FRS structure in which combined FRS's are located at NASNI and NORVA. The need for NORVA to procure additional simulators, and the large number of PCS moves required quickly overrides the other cost factors and any potential attributes.

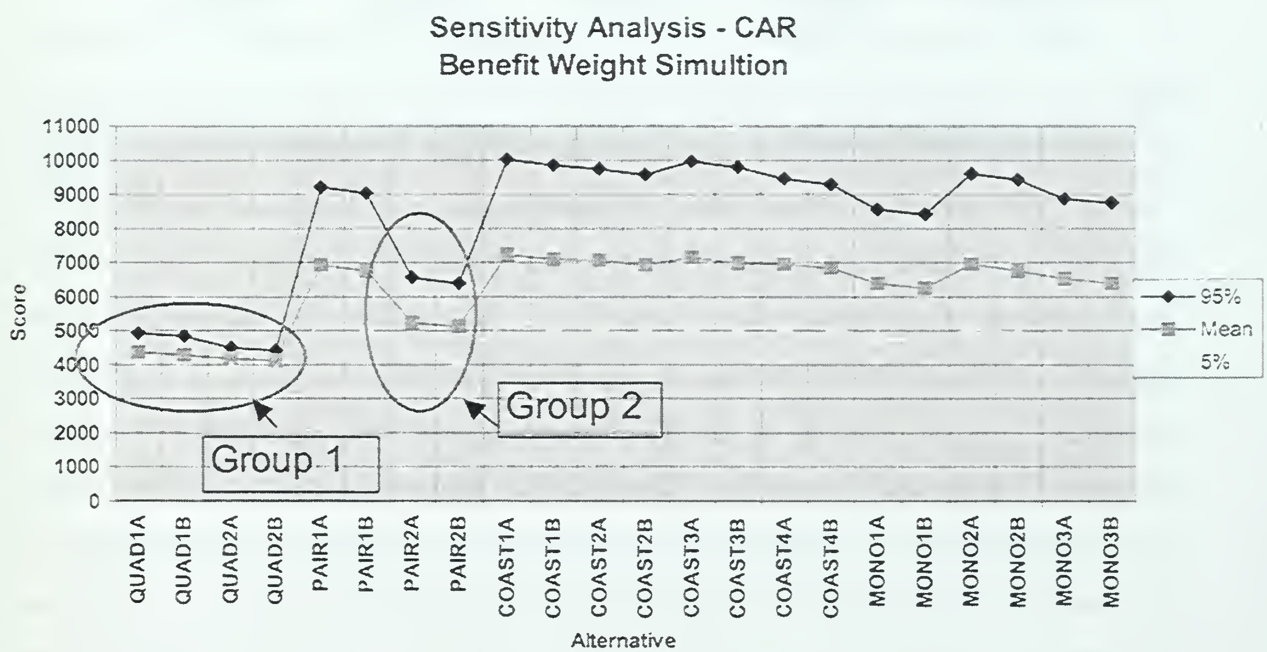

Figure 9: Sensitivity Analysis - CAR Attribute Weight Simulation. With sensitivity analysis, the groupings of the alternatives remain in tact. While the Group 1 alternatives have high CAR's and slightly wider ranges. these alternatives are still preferred when compared to those in Group 2 and Group 3. Quad alternative 2B remains the single most preferred alternative with the lowest CAR and tightest interval.

2. Tornado Graphs

Tornado graphs were created to further analyze the impact of varying the three input data categories on total cost. The alternatives on Group1 and Group 2 were evaluated by varying FMC/MC Rate, cost per flight hour, and the procurement cost separately. The resulting total cost was calculated for each case and compared to the baseline total cost. The resulting plots illustrate how sensitive the total cost is to varying each of these three input data categories. All six graphs revealed similar effects of varying the three input data categories. Figure 10, depicts the results for Alternative Quad 2B, the least cost alternative. The tornado plots for the remaining Group 1 and Group 2 alternatives may be found in Appendix C.

The tornado plot reveals that the FMC/MC rates have the biggest impact on the total cost for the given alternatives. Varying the FMC/MC rates, results in a change to the number of aircraft required for each alternative. High FMC/MC rates require fewer aircraft, thus fewer aircraft are procured resulting in a lower cost. Conversely, low FMC/MC rates demand more aircraft to complete the specified syllabus. The FMC/MC rate tends to have a negative effect on the total cost due to how the number of aircraft required is selected. In determining the baseline aircraft required values, as specified in Appendix A, if the number of aircraft required is less than the squadron's wartime inventory (a static value for each airframe based on projected utilization in time of war), the wartime inventory is preferred. This ensures that the wartime demand is covered. If the squadron's requirements are such that the number of aircraft required is greater than the wartime inventory, then the higher value is selected. Varying the FMC/MC rates reveals that the number of aircraft required tends to be lowered by high FMC/MC rates, but only slightly affected by low FMC/MC rates.

Varying Cost per Flight Hour also has an impact on the total cost for each alternative. Figure 10 shows that total cost is not as sensitive to varying cost per flight hour as with varying FMC/MC rates, but sensitivity does exist. Finally, procurement cost has a slight effect on total cost, but not to the extent of the previous two cost categories.

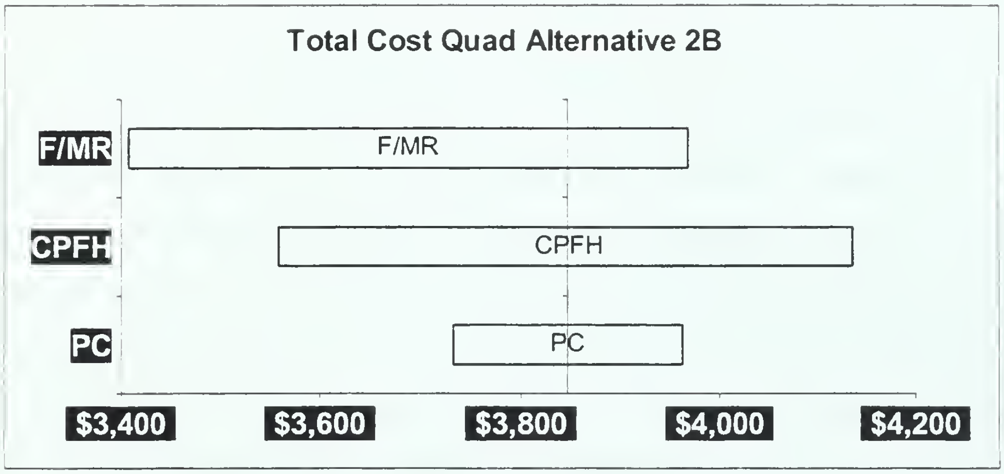

Figure 10: Tornado Graph for Total Cost of Quad Alternative 2B. The alternatives in Group 1 and Group 2 were most sensitive to the change in FMC/MC rates. Varying these maintenance rates has a decreasing impact on the total cost. Cost per flight hour and procurement cost also impact the total cost of these alternatives, but not to the extent of FMC/MC rates.

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VII. CONCLUSIONS

The implementation of the Helicopter Master Plan involves several significant and dynamic issues. Not only will this unprecedented community reconfiguration impact the operational squadrons and their missions, it will enact a change in the manner in which helicopter pilots are trained in the new aircraft. A critical issue to address is the structure, or potential restructuring of the Fleet Replacement Squadron organization. The introduction of the SH-60R and CH-60S, subsequent integration of the existing seven T/M/S into two, and a common cockpit syllabus, provide the helicopter community an opportunity to improve the efficiency of their organization. The Additive Weighting and Scaling Model was used to address this issue. Simulations of potentially varying attributes were then applied to test the sensitivity of the results.

If cost were the only concern, a group of three alternatives, Quad alternative 2B, Pair alternative 2B, and Quad alternative 1B stood out from the remainder of the alternatives. These three have the lowest total cost relative to the remainder of the options. These options all consider configurations in which FRS training is located on both coasts, with separate FRS per T/M/S. Quad alternative 2B has the lowest total cost overall.

In considering raw attribute scores, Quad Option 1 is preferred in the majority of the attribute categories. Within Quad Option 1, Quad alternative 1A and 1B are preferred in two categories as are Quad alternatives 2A and 2B.

In the PCS Moves category, Quad alternatives 2A and 2B came out with the best raw attribute score tied with Pair alternatives 2A and 2B (combined HR and HS training on each coast). Regarding utility rates, Quad Option 1 alternatives using the common cockpit syllabus come out with the best score. In these alternatives, flying hours are the most spread out among squadrons and the specified number of aircraft required. Coast alternatives 2B and 3B achieved the best attribute score with respect to the officer-to-enlisted ratio attribute. However, the scores in this category did not vary by a large amount. It is expected that more specific manpower contributions will be available in the future and provided more succinct results. In the case where the number of squadrons

disestablished was decided to be the most important attribute category, Quad alternative 1B had the best cost-attribute ratio. Both Quad alternatives 1B and 1A have the best score achieved in this category, however Quad alternative 1B has a lower total cost than Quad alternative 1A and would therefore be the preferred option. Similarly, when considering the number of squadrons established as the most important attribute, the same options receive the same relative ranking. Quad options 1A and 1B require only that the small FRS in NORVA become a stand alone FRS.

Next individually weighted attribute scores were considered. Regarding PCS moves, Quad alternatives 2A, 2B, and Pair alternatives 2A and 2B are preferred in this category; their CAR scores are noticeably lower than the remaining alternatives by a significant amount. Considering utility rates, Quad alternative 2B achieves the best CAR. Combined with a lower operating and procurement cost, training Plan B results in a more preferential utility rate to training Plan A. Quad alternative 1B also has the top score with respect to the utility rate attribute. Additionally, Quad alternative 1B involves three geographically different air stations compared to the two air stations in Quad alternative 2B. However, Quad alternative 2B's lower total cost makes it the preferred alternative. When the officer-to-enlisted attribute category receives 100% weight, Coast alternative 3B receives the highest score. The difference between this alternative and the remaining alternatives is not impressive. In the case where the number of squadrons disestablished was selected as the most important attribute category, Quad alternative 1B had the best cost-attribute ratio. Both Quad alternative 1B and 1A have the best score achieved in this attribute category, however Quad alternative 1B has a lower total cost than Quad alternative 1A and would therefore be the preferred option. Similarly, when considering the number of squadrons established as the most important attribute, the same alternatives earn the same relative ranking.

The results of the weight attribute simulation break out three distinct groupings of alternatives. Group 1 ("most preferred"), consisting of Quad alternatives 1A, 1B, 2A, and 2B, breaks out as the clear favorite. These alternatives have the lowest mean and the tightest range. These options all involve multiple coast and T/M/S specific squadrons.

Quad alternative 2B has the overall lowest mean CAR and the overall tightest range. This means that a decision-maker can consider this option as less variable than the others. The preference for these alternatives is logical considering the majority of top scores received in the attribute categories involved Quad Option 1 alternatives.

Group 2 ("next best"), consists of Pair alternatives 2A and 2B. These alternatives also have low mean values. They are similar to the options in Group 1 with the difference that the Group 2 alternatives involve combined squadrons that are more sensitive to weights. The mean values for this group are higher than the highest highs of Group 1. The lowest lows for Group 2 are still higher that the means of Quad alternatives 1A and 1B and higher than the highest highs of Quad alternatives 2A and 2B.

Group three consists of the remainder of the alternatives ("not recommended"). With the exception of Coast alternatives 2B and 3B, these alternatives have failed to reach the top score in any category. Coast alternative 3B received the best score for the officer-to-enlisted attribute alone. The lowest lows for these alternatives have CARs that are still higher than the highest high CAR values of Group 1 and higher than the means of Group 2.

Sensitivity analysis of FMC/MC rates, cost per flight hour, and procurement cost and the resulting impact on the total cost and Cost Attribute Ration revealed that, with respect to the CAR score, the ranking of the alternatives do not dramatically change with considerable variation to these inputs. The groups determined in the selection of alternatives remain in tact.

The interval surrounding Quad alternative 2B, the most preferred of Group 1, is not as tight when the sensitivity analysis attributes are varied. However, it does remain as the lowest and least risky alternative of Group 1 and of the remainder of the alternatives.

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APPENDIX A: SQUADRON REQUIREMENT FORMULATION

The model used to determine the number of aircraft, instructor pilots, instructor enlisted, total flight hours, and simulators required for each alternative were generated using the Naval Aviation Production Planning Improvement (NAPPI) Production Planning Factor (PPF) model. The PPFs are used as a standardized planning tool for annual instructor, aircraft, simulator and flight hour requirements.

The PPF model has one goal: to determine FRS resources required to produce aviators demanded by the Fleet. CNAP/CNAL approved the initial FRS PPF inputs in January 1999 and forwarded to the CNO N889. The CNAP N00 directed FRS implementation in May 1998.

<u>Flight / Simulator Hours Required</u> (Model is same for aircraft or simulators)

1. Total Flight Hours = Hours/Student * Number of Students
2. Hours/Student = Syllabus Hours + Support Hours + Overhead Hours
3. Support Hours = Fair Share of Dedicated lead/Chase/Safety Hours
4. Overhead Hours =(Syllabus + Support Hours) * (Overhead Rate+Attrition Rate/2)

<u>Instructor Hours Required</u> (Model is same for aircraft or simulators)

1. Total Instructor Hours = Inst Hours/Student * Number of Students
2. Inst Hrs/Student = Inst Syllabus Hrs + Inst Supt Hrs + Inst Ovrhd Hrs
3. Inst Supt Hrs = Fair Share of "Dedicated" Inst Supt Hrs
4. Inst Ovrhd Hrs = (Inst Syl Hrs + Inst Supt Hrs)

   *(1 + Ovrhd Rate + Attrition Rate/2)

<u>Academic Instructor Hours Required</u>

1. Academic Inst Hours Required =

   Syl Inst Hrs per Student* Number of Students/Avg Students per Class

Hours per Aircraft per Day

1. Hours per Aircraft per Day =

   (Aircraft Workday – (Hrs per Sortie*Sortie per Day))

   * RFT Rate * Sked Efficiency Rate * Weather Loss Rate

Flight Hours per Aircraft per Year (Aircraft Utilization – UTE)

1. Acft Ute = Flight Hrs per Day * Training Days per Year

Number of Aircraft Required

1. Aircraft Required = Flight Hrs Required / Aircraft Ute

   Note: Round up @ 0.15)

Ready For Training (RFT) Rates

1. RFT = (Number FMC Event / Syl Events)*FMC Rate

   + (Number FMC Events/Syl Events)*MC Rate

   - Percent in Scheduled Maintenance

Fixed Syllabus Characteristics

Annual Training Days

1. 52 weeks @ 5 days per week = 260 Days
2. Less:
   a. Holiday Stand down 10 days
   b. Federal Holidays 9 Days
   c. Change of Command 1 Day
   d. Trng, Maint, PRT, etc. 1 Day/Month
2. Total = 228 Days

Instructor Availability

1. 228 Days per year @ 8 hours a day
2. Less:

a.	Ground job	2 Hrs/Day	(25%)
b.	Duty/Watch	6 Days/Yr	(3%)
c.	TAD, Flt Phys, etc.	5 Days/Yr	(2%)
d.	Leave/Liberty	10 Days/Yr	(4%)

3. Total = 66% IP availability per year, or

   8 Hrs per Day, 151 Days per Year.

<u>Required Inputs</u> (General – historic, calculated or estimated)

Instructor Data

- Instructor Workday (Hrs/Day)
- Student Contact Time (Hrs/Event)
- Simulator Contact Time (Hrs/Event)
- Instructor Pilot (IP) Availability (%)
- Instructor Enlisted (IE) Availability (%)
- Average IP Tour Length (Months)
- Average IE Tour Length (Months)
- Average IP Instructor Under Training (IUT) Syllabus Length (Months)
- Average IE IUT Syllabus Length (Months)

Estimated Overhead Data

- INCOMP/ABORT (%)
- REFLY (%)
- IUT (%)
- TEST/FCF (%)

- SERVICE (%)
- LOGISTICS (%)
- STAN/STASH (%)
- TRANSIT (%)

Aircraft Maintenance Data

- HISTORICAL % FMC (%)
- HISTORICAL % MC (%)
- PCT IN SKED MAINT (%)
- TURN-AROUND-TIME (TAT) (Hrs)
- ACFT WORK DAY (Hrs)

Simulator Maintenance Data (Simulator Type "A")

- SIM % FMC A (%)
- SIM % MC A (%)
- TAT SIM A (Hrs)
- SIM DAY A (Hrs)
- SIMULATOR OVERHEAD (%)

Misc Data

- ANNUAL FLY DAYS (Days)
- SKED INEFFICIENCY INDEX) (%)
- CNX WEATHER (%)

Required Inputs (Student Category specific – historic, calculated or estimated)

Annual Training Requirement

- REQUIRED OUTPUT/DEMAND "Student throughput" (Students)

- AVG ATTRITION PCT (%)

Syllabus Data

- SYLLABUS/FLT EVENTS (Events)
- SYLLABUS HOURS (Hrs)
- SYL IP HOURS (Hrs)
- SYL IE HOURS (Hrs)
- SUPT IP HOURS (Hrs)
- SUPT IE HOURS (Hrs)

Syllabus Resource Availability Requirements

- # SYL EVT FMC (Events)
- # SYL EVT MC (Events)
- TOTAL SYL EVTENTS (Events)

Academic/Flight Support

- ACADEMIC/FS HOURS (Hrs)
- AVG CLASS SIZE (Students)
- ACADEMIC IP HOURS (Hrs)
- ACADEMIC IE HOURS (Hrs)

Additional Manpower Requirements

- MANPOWER FACTORS
- ROC/POE ADDITIONAL TASKING REQUIREMENTS
- ANNUAL TASKING
- TASK MANPOWER
- TASK ANNUAL MAN-HOURS
- OVERHEAD-BILLET REQUIRMENT

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APPENDIX B: ALTERNATE SQUADRON PRESENTATION

OPTION I:

OPTION IA	Squadron	PAA (R)	PAA (S)	IP	IUT	SIM (R)	SIM (S)
	HR-1 (NASNI)	16	0	19	2	3	0
G1	HS-1 (NASNI)	0	17	21	2	0	2
	HR-2 (NAS J/M)	16	0	21	2	3	0
	HS-2 (NORVA)	0	16	19	2	0	2
	HR-1 (NASNI)	16	0	19	2	3	0
G2	HS-1 (NASNI)	0	17	21	2	0	2
	HR-2 (NAS J/M)	16	0	21	2	3	0
	HS-2 (NAS J/M)	0	16	19	2	0	2
OPTION IB	**Squadron**	**PAA (R)**	**PAA (S)**	**IP**	**IUT**	**SIM (R)**	**SIM (S)**
	HR-1 (NASNI)	11	5	19	2	3	0
	HS-1 (NASNI)	0	17	21	2	0	2
G1							
	HR-2 (NAS J/M)	12	5	21	2	3	0
	HS-2 (NORVA)	0	16	19	2	0	2
	HR-1 (NASNI)	11	5	19	2	3	0
	HS-1 (NASNI)	0	17	21	2	0	2
G2							
	HR-2 (NAS J/M)	12	5	21	2	3	0
	HS-2 (NAS J/M)	0	16	21	2	0	2

OPTION 2 :

OPTION IIA	Squadron	PAA (R)	PAA (S)	IP	IUT	SIM (R)	SIM (S)
G1	HRS-1 (NASNI)	16	17	40	3	3	2
	HRS-2 (NAS NORVA)	16	16	40	3	3	2
G2	HRS-1 (NASNI)	16	17	40	3	3	2
	HRS-2 (NAS J/M)	16	16	40	3	3	2
OPTION IIB	**Squadron**	**PAA (R)**	**PAA (S)**	**IP**	**IUT**	**SIM (R)**	**SIM (S)**
G1	HRS-1 (NASNI)	11	22	40	3	3	2
	HRS-2 (NAS NORVA)	12	21	39	3	3	2
G2	HRS-1 (NASNI)	11	22	40	3	3	2
	HRS-2 (NAS J/M)	12	21	39	3	3	2

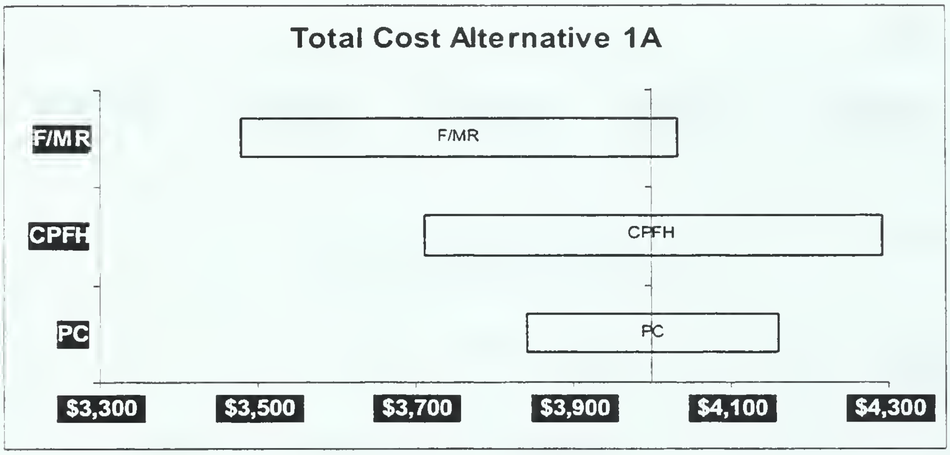
OPTION 3:

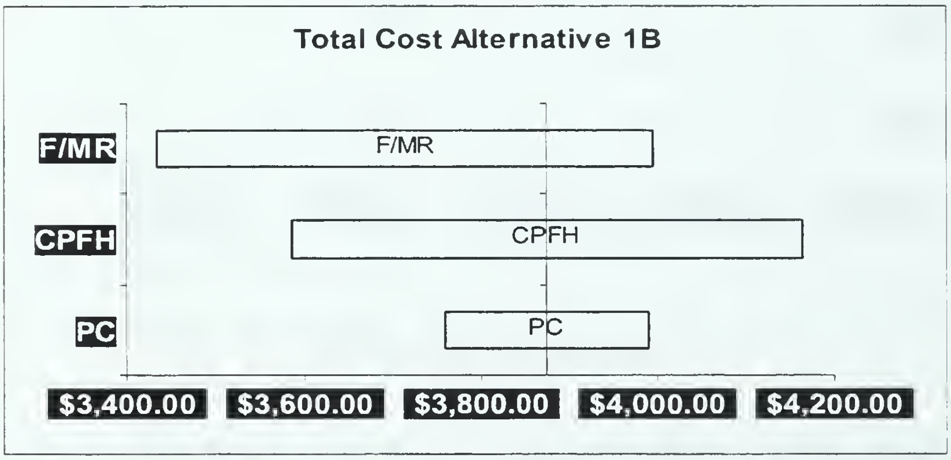
OPTION IIIA	Squadron	PAA (R)	PAA (S)	IP	IUT	SIM (R)	SIM (S)
G1	HR (NASNI)	31	0	37	3	5	0
	HS (NORVA)	0	32	37	3	0	3
G2	HR (NASNI)	31	0	37	3	5	0
	HS (NAS J/M)	0	32	37	3	0	3
G3	HS (NASNI)	0	32	36	3	0	3
	HR (NASNI)	31	0	37	3	5	0
G4	HS (NASNI)	0	32	36	3	0	3
	HR (NAS J/M)	31	0	38	3	5	0
OPTION IIIB	**Squadron**	**PAA (R)**	**PAA (S)**	**IP**	**IUT**	**SIM (R)**	**SIM (S)**
G1	HR (NASNI)	23	10	39	3	5	0
	HS (NORVA)	0	32	37	3	0	3
G2	HR (NASNI)	23	10	39	3	5	0
	HS (NAS J/M)	0	32	37	3	0	3
G3	HS (NASNI)	0	32	36	3	0	3
	HR (NASNI)	23	10	39	3	5	0
G4	HS (NASNI)	0	32	36	3	0	3
	HR (NAS J/M)	23	10	40	3	5	0

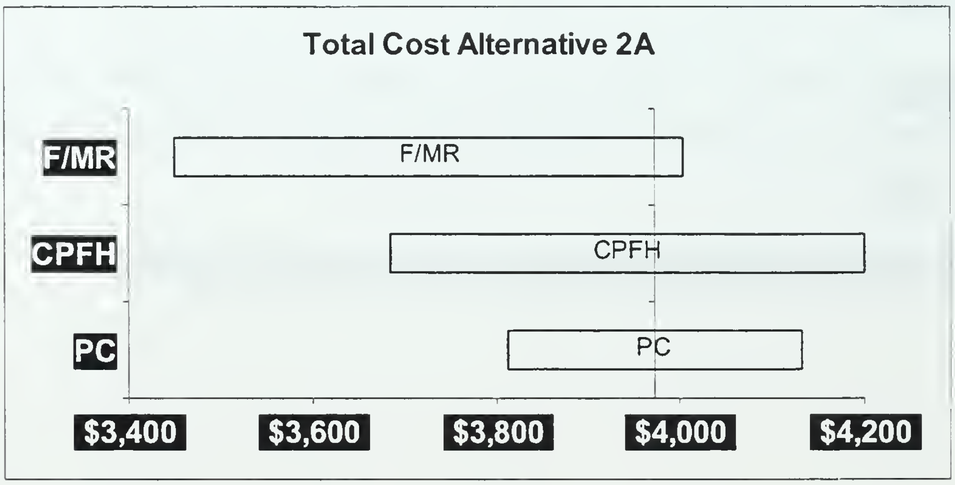
OPTION 4:

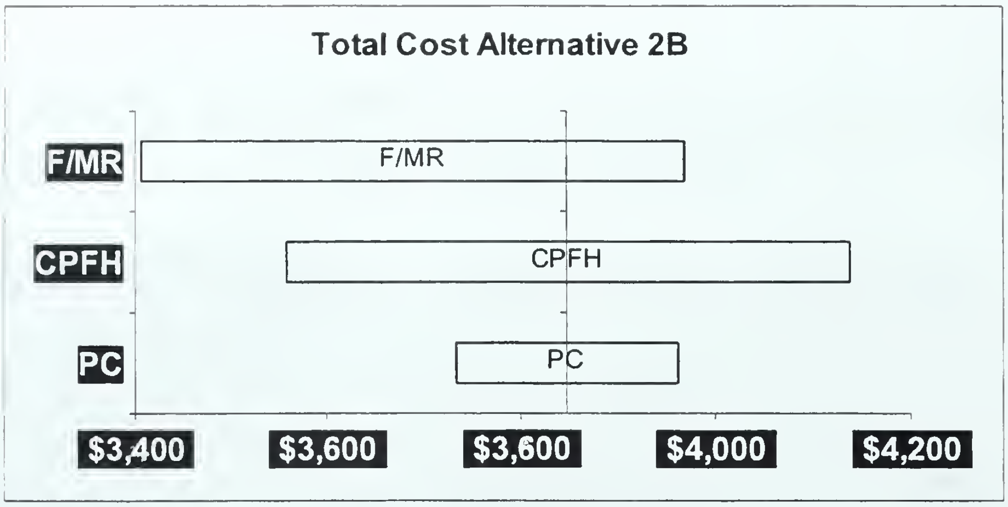
OPTION IVA	Squadron	PAA (R)	PAA (S)	IP	IUT	SIM (R)	SIM (S)
G1	HRS (NASNI)	31	32	78	6	5	3
G2	HRS (NORVA)	31	32	80	6	5	3
G3	HRS (NAS J/M)	31	32	80	6	5	3
OPTION IVB	**Squadron**	**PAA (R)**	**PAA (S)**	**IP**	**IUT**	**SIM (R)**	**SIM (S)**
G1	HRS (NASNI)	23	42	78	6	5	3
G2	HRS (NORVA)	23	42	80	6	5	3
G3	HRS (NAS J/M)	23	42	80	6	5	3

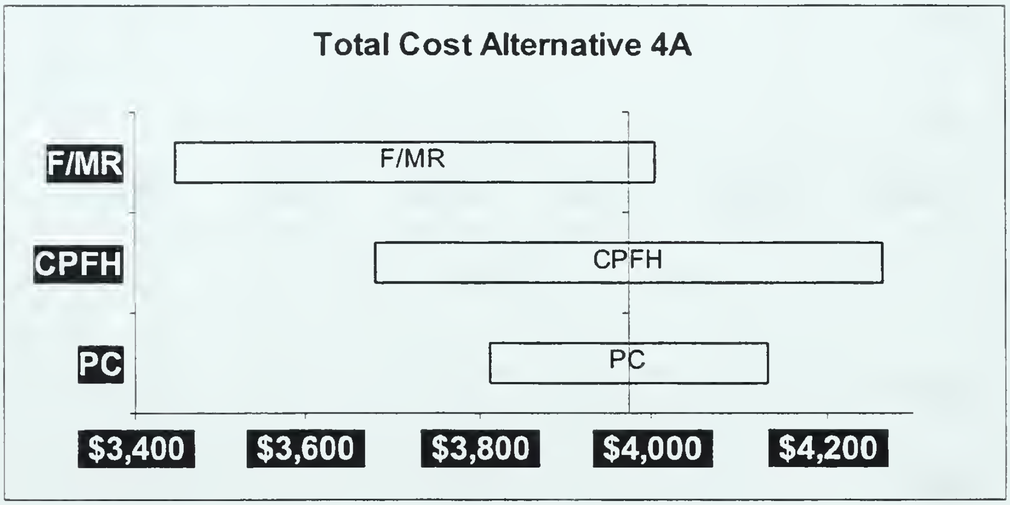
APPENDIX C: TORNADO GRAPHS FOR SNESITIVITY ANALYSIS ON GROUP 1 AN GROUP 2 ALTERNATIVES

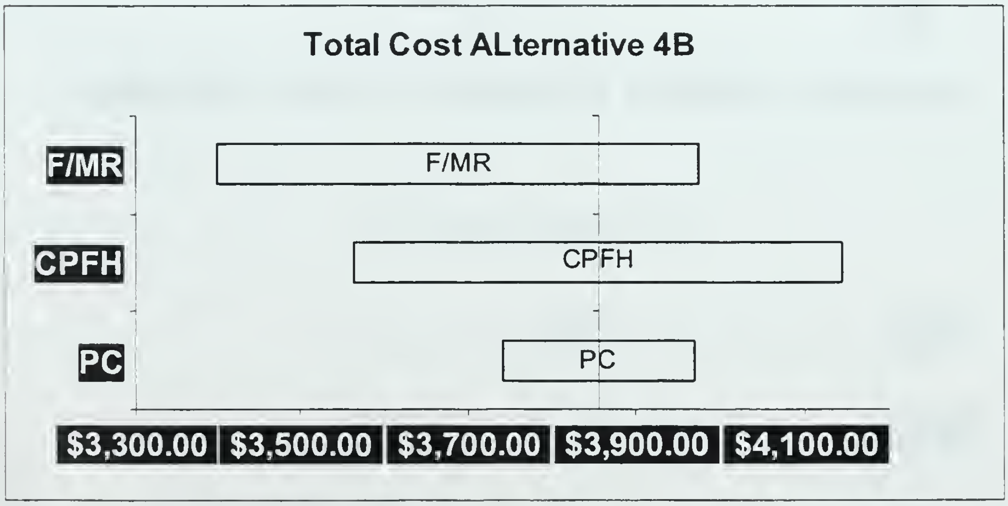







Total Cost Alternative 2B
F/MR
CPFH
PC
F/MR
CPFH
PC
$3,400
$3,600
$3,600
$4,000
$4,200


Total Cost Alternative 4A
F/MR
CPFH
PC
F/MR
CPFH
PC
$3,400
$3,600
$3,800
$4,000
$4,200


Total Cost ALternative 4B
F/MR
CPFH
PC
F/MR
CPFH
PC
$3,300.00
$3,500.00
$3,700.00
$3,900.00
$4,100.00

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